BENDING TECHNOLOGY
/
A COLLABORATIVE APPROACH TOWARDS DIGITAL FABRICATION

// DIEGO ZAMORA BARROSO

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II. ABSTRACT

This practice-based research investigates how interdisciplinary collaborations can help creative practitioners overcome perceived barriers and the notion of risk when approaching emerging technologies. This research aims to present an understanding of methods and theory that focuses on the exploration of technology within creative, collaborative contexts. More specifically, makers and craftspeople using desktop 3D printing in Scotland. The fluidity and unique qualities of this technology challenges established notions of expertise, labour and materiality. I explore the rhetorical notion of 'disruptive technologies' through contextual research, collaborative workshops, one-to-one experiments and reflective practice.

Information and communication technologies are blurring the roles and participation of audiences and producers (Gauntlett, 2011; Ritzer and Jurgenson, 2010; Toffler, 1980); as a consequence, online communities are becoming centres of development and innovation. These communities share some traits with Von Hippel´s definition of creative communities in which "user-led innovation" emerges (Von Hippel, 2005). However, the role that these communities of practice play, such as hackers, makers and users on the fringes of technological adoption, remains under studied. The debate on how to analyse these environments is split between Science Technology Studies (STS) Scholarship and design-centred approaches (Pinch and Oudshoorn, 2008). STS scholarship is dominated by the argument that technological development is not independent of social factors (e.g. Pinch and Bijker, 1984). However, cultural explanations remain anthropocentric and fail to recognise the role of the industrial drive in engineering and design (Sporton, 2015). This thesis explores this divide by proposing a framework developed through case studies, workshops, ethnographic research methods and participatory action research.

Craft-related practices are exemplary for their relation to process and material exploration (Adamson, 2007a). The modernisation of local economies and the models of post-industrial production could displace the role of those practitioners who lack opportunities to explore emerging technologies (Atkinson et al., 2009; Bunnell, 2004; Marshall, 1999, 2008a). In an increasingly digital era, the relationship between collaborative creative practice, direct material manipulation and digital fabrication technologies need to be the subject to analysis.

As an example of an emerging and purportedly 'disruptive' technology, 3D printing has been touted as a revolution in manufacturing, allegedly captivating the mind of consumers and creatives (Anderson, 2012; Berman, 2012). 3D printing and the online communities coalescing around it are creating new territories through collaboration, and this emerging technology brings to material practice a fluidity that belonged to the digital alone. Early adopters and artists, such as Michael Eden, Neri Oxman and Geoffrey Mann (Johnston, 2015), contributed to the development of a narrative that is still being contested by creative practitioners. This context offers a fertile environment for understanding the role of creative practitioners in technological dissemination. This relation is explored through hybrid research methodologies in which I act as a facilitator, a hacker, collaborator and sometimes as a technical service provider. This thesis sets out to question the materiality of 3D printing, its role as a creative tool, and challenge the perception of its impact on handmade practices.

From this body of creative practice and reflection, longitudinal collaborations are presented that analyse different stages in creative, collaborative relationships mediated by technology - that is when a technology is at the centre of the creative relationship. Case study one focuses on the development of a method for creating a hybrid between 3D printing and textile design. Case study two examines the development of an image-based approach towards generating geometry that amalgamates painting, 3D modelling and printing. Case study three focuses on the potential use of 3D printers for generating media to accelerate processes within embroidery. These case studies and workshops have provided an opportunity to develop digitally mediated collaborations, leading to insights into collaborative practice and perceptions around emerging technologies within craft-based practices; thus, providing a creative context for the research and positioning this project within the field.

Reflective practice is used as the primary mode of inquiry. This offers a unique insight into the development of a reflexive approach towards collaboration. The original contribution to knowledge of this research project lies in the proposal of a method for creating and analysing digitally mediated creative collaborations, as well as challenging techno-deterministic conceptions of technological dissemination. I propose to 'bend technology' as a low-level approach towards emerging technologies. This thesis includes a series of workshops, a portfolio of creative experiments, case studies and a body of 3D printed samples and works that range from conceptual artistic interventions to novel methods for 3D printing.

III. ACKNOWLEDGMENTS

Before mentioning bodies or institutions, I must thank my family, for support and encouragement. Learning together is at the core of this thesis, and I cannot think of anyone better at that than my parents. At the same time, this project is driven by an inner surge of exploration and self-reflection while trying to unlock my research I managed to find a hidden dimension within me, opening new possibilities and moving away from preconceptions about myself and identity. At some point, I realised I had to kill what I could be, so I could work on what I am.

This research was initially funded by Design in Action, an AHRC funded project across Scottish Higher education institutions. The cohort of peers and colleagues that I would like to thank is far too big to be represented adequately here. However, I could not miss thanking all the support from non-academic staff that helped me all along the way in Edinburgh College of Art. I am grateful for the opportunities and questions raised by my supervisors Simon Biggs, Richard Coyne, Chirs Speed and Debbie Maxwell. Chris and Debbie surpassed the expectations of what a Supervisor could be with their unconditional support during the interminable lows and highs of this journey.

Along the way, I made new acquaintances that acted as advisors and became close friends such as Jessamy Kelly and Juliette MacDonald. Additionally, I must mention my collaborators; Mark Connolly, Jen Deschenes and Morvern Odling. This research would not have been possible without their collaboration and friendship.

I am incredibly thankful to Hope Robertson for the help provided as a proof-reader and Andrea Maestro for the graphic design. I could not have gone through the early stages of this research without the support of Julieta Gomez, in addition to my two *crazy,* yet supportive (and sometimes annoying) Scottish brothers; Wendy Cava and David Martinez. Today I find myself opening the horizons of my professional career in the company of Raquel Granda who suffered by my side on the last year of the write-up and kept me fuelled with cake and sweet marmalade. Thank you, thank you all.

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VII. GLOSSARY OF TERMS

Digitally mediated collaboration: a collaboration in which digital technology plays a central role.

Boolean operators: simple commands used in 3D design to combine simple geometries to create complex structures. Boolean operators are often presented as AND, OR and NOT within a modelling context AND is interpreted as the intersection of two geometries, OR; the combination of two geometries, NOT; as the subtraction of one geometry from the other.

Geometric primitives: the minimal geometrical unit in a 3D design environment. These are often defined as cube, cylinder, sphere, cone, pyramid and torus. They are used to build more complex geometries by using Boolean operators and transformations.

Three-dimensional mesh and nodes: in 3D environments, meshes are visual representations of geometries and surfaces. A mesh is a partition of space into elements. These elements are known as cells. These cells are defined by lines that converge in points, these points are referred as nodes and are the most basic unit for editing a three-dimensional mesh. By dragging and pulling nodes we can modify the geometry of a mesh.

Three-dimensional modelling: Its known as the act of designing and modelling objects in a virtual environment. This is often done with Computer Aided Design (CAD) software.

Three-dimensional design environment: it is the virtual space in which virtual objects, forms and models can be handled and manipulated.

"Healthy" 3D model: for this thesis, I will consider a "healthy" 3D model as a virtual geometry that is ready to be 3D printed without requiring editing. It is common, when experimenting with 3D printing to find numerous faults in a 3D print, in many cases these are produced by a flaw in the 3D model.

Digital fabrication: digital fabrication is a production process where the machine used is controlled by a computer.

PLA, ABS: are the most common 3D printing materials. Polylactic acid or polylactide (PLA) is a biodegradable thermoplastic made with corn starch. Acrylonitrile butadiene styrene (ABS) is one of the most common thermoplastics (often used in household electro domestics).

FDM: Fused Deposition Modelling is an additive manufacturing process, it consists of the deposition of fused material on layers to produce a geometry.

Disruptive technology: a disruptive technology is considered as one that can modify the environment in which it develops.

Follow-up collaborations: Collaborations that further explored issues raised during workshops and other research activities.

1. INTRODUCTION

This research is part of Design in Action; an interdisciplinary research project developed in partnership between five Scottish universities. The scope of the project was to analyse the role of information communication technologies (ICT) within rural Scotland. This thesis develops from this line of enquiry to approach practitioners that are connected to craft practices which are willing to learn about desktop 3D printing.

This thesis offers insight into the perceived barriers for creative exploration of desktop 3D printing within craft-based studio practices. These perceptions, I argue, are influenced by the narratives associated with the notion of 'disruptive technology'. I explore this rhetorical notion through contextual research, collaborative workshops, one-to-one experiments and reflective practice. The fluidity and unique qualities of desktop 3D printing challenge established notions of expertise, labour and materiality.

1.1. REFLECTIVE SUMMARY

My mother is a craft practitioner, my sister an artist. Somehow, I ended up studying engineering. In 2005 my design engineering studies led me to participate in a cultural and professional exchange in the south of Spain, design students were to collaborate with potters to create a new line of products. This exchange aimed at providing the young design students with a hands-on industry experience. In return, craft practitioners were expected to capitalise on the new designs with hopes of revamping revenue. It did not work. The once thriving community of potters was agonising, unable to compete with mass-manufactured imports. This was a life experience; secrets passed down generation after generation were no longer looked after, the skills and the techniques were on the brink of disappearance. This experience has been a source of motivation and curiosity ever since. These types of communities of practice are met with technological and competitive challenges at an increasing pace, yet technological experimentation and adaptation to new technical flows do not seem to match the rate of innovation. Furthermore, hybrid digital-analogue processes are often contested within craft circles.

This research has profoundly influenced the way I perceive my practice as a designer and engineer, this research through design is rooted in 'knowing in action'(Schön, 1983), notions of tacit knowledge have been contested from a contemporary point of view, where work environments are increasingly digital. Daniel Charny's publication, the *Power of Making, 2011*, offers perspective into contemporary making were the notions of labour, craft and production are explored. Through interaction with practitioners, I have gained insight into the processes of technological dissemination from a cultural point of view where social and material practices are examined (Hutchinson et al., 2003). As such, the material outputs produced through this research are analysed as a form of knowledge (Margetts, 2011); the products of collaborations and workshops are used to prompt discussion and analysis among other participants.

1.2. RESEARCH CONTEXT AND RATIONALE

Generational differences exist when using and exploring digital technologies (Ariss et al., 2000; Loges and Jung, 2001). The coming generations of practitioners are profoundly influenced by the fact that digital processes are increasingly common in higher education institutions. Additionally, such institutions are creating and adopting 'beyond discipline' positions, in which transdisciplinary experimentation is encouraged. This is often supported and facilitated by emerging digital tools (Bøhn, 1997; Heinze and Procter, 2004; Hicks et al., 2001; Procter, 2003). The exploration of digital fabrication methods within a creative context has been met with the mindset of those who do not necessarily see technology as progress. This shatters assumptions about professions and definitions of disciplines. The interaction of younger students and practitioners with more seasoned professionals created debates about the nature of technological flows and the skills sets associated with them.

The use of 3D printing in a craft context has been described as 'disruptive', and 3D printing has been touted as a revolution in manufacturing, allegedly captivating the mind of consumers and creatives (Anderson, 2012; Berman, 2012). The interaction and boundaries between the professional and the amateur is being increasingly contested (Beegan and Atkinson, 2008). This causes tension among practitioners who feel that they lack opportunities to engage with emerging digital fabrication technologies (Zamora et al., 2013). To further explore this divide I use hybrid research methodologies in which I act as a facilitator, a hacker, collaborator and sometimes as a technical service provider. The onset of this state of flux of my practice offers further insight on the evolving process of teaching and learning how to teach others to use the supporting processes of 3D printing.

1.3. AIMS AND RESEARCH QUESTION

This multiple-method approach, which is rooted in reflective, creative practice, is driven and directed by the following questions: Within the domain of craft and making, what are the main issues and perceptions when approaching desktop 3D printing? Further analysis is sought over what barriers exist that creative practitioners might encounter when approaching an emergent technology? And what is the role of collaboration in the learning and development of knowledge in a technology-mediated context?

The line of inquiry is driven the following aims:

Aim 1: To capture perceptions and divisions generated by the rhetoric of 3D printing within creative practices in Scotland. This is done by organising workshops and the analysis of quantitative data.

Aim 2: To demonstrate the creative and practical benefits of collaborative practice as a mode of engagement with emerging technologies. This is explored through collaborations and workshops using 3D printers and complimentary processes.

Aim 3: To articulate and analyse the role of direct material manipulation within craft practices as a factor for the dissemination of emerging technologies. Self-reflection and development of practice are at the core of this, as well as being evident in the data gathered through other methods.

To better understand the creative spaces between adoption and rejection of new technologies, this practice-led research considers the practices surrounding desktop 3D printing that are associated with craft practice and collaborative making, especially within the domain of direct material manipulation.

1.4. METHODS AND DATA

Reflective practice is used as the primary mode of inquiry. This offers a unique insight into the development of an object-oriented and reflective approach towards collaboration. The original contribution to knowledge of this research project lies in the proposal of a method for creating and analysing digitally-mediated creative collaborations, as well as challenging techno-deterministic conceptions of technological dissemination. I propose to 'bend technology' as a low-level approach towards emerging technologies. This thesis includes a series of workshops, a portfolio of creative experiments, case studies and a body of 3D printed samples and works that range from conceptual artistic interventions to novel methods for 3D printing.

Participatory Action Research (PAR), is central in the development of this research, however, with the development of deeper relationships with my participants my ontological point of view changed. Thus, bringing this research closer to an ethnography of the self, giving central role to the personal narrative (Ellis, 2004)

1.5. TIMEFRAME AND STRUCTURE

This thesis is presented in eight chapters and four appendixes in which I present supporting documents. Additionally, a portfolio of collaborations and creative experiments is attached. Chapter two offers a contextual review where relevant practices and scholarly debates are presented. Chapter three offers a review of the methodological framework and practicalities associated with the methods selected. Chapter four presents the activities and data gathered during the workshops organised. Chapter five and six, present the personal exploration of practice on my own and collaboratively. Finally, chapter seven introduces the discussion.

Given the number of activities and data gathered I decided to present it as it was gathered chronologically. To simplify the presentation of data I have separated the workshops, case studies and self-reflection in individual chapters, however, insights from the three activities are combined in the discussion. In figure 1-1, I present a timeline of the research and timing of activities, this helps understanding the sequence of engagement and collaborations.

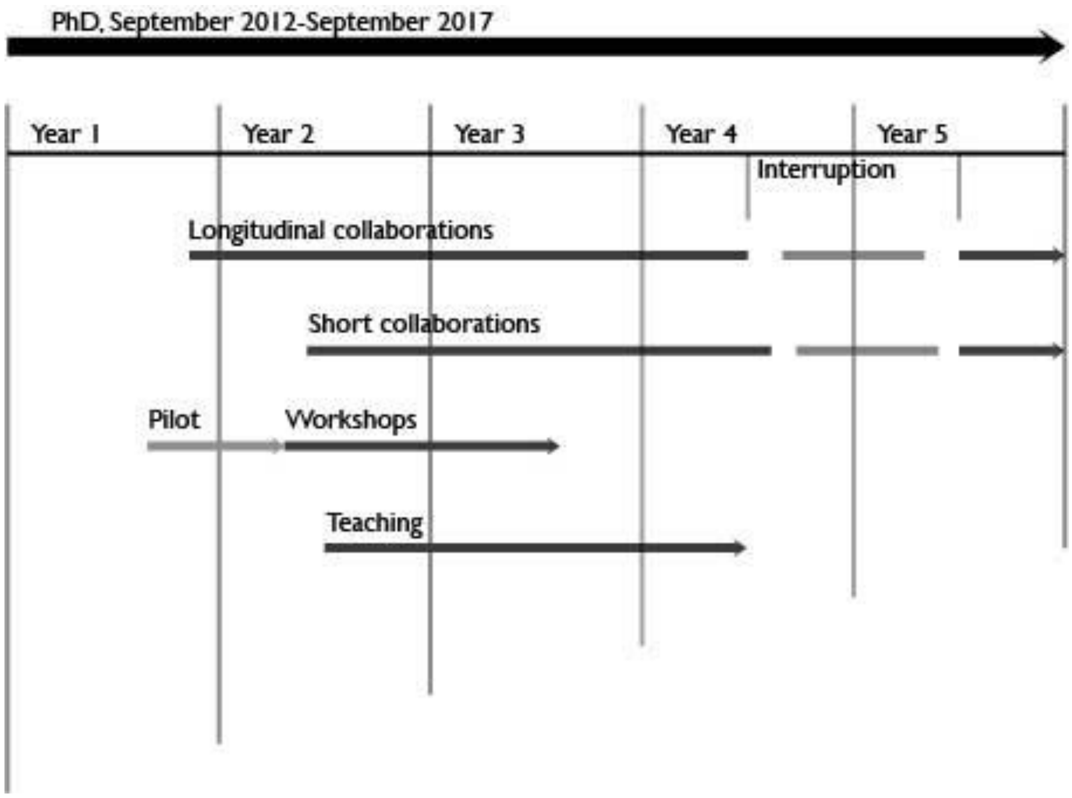

Figure 1-1-Thesis timeline.

2. CONTEXTUAL REVIEW

This Chapter sets out to establish contextual reference points by mapping the context of the field of digital fabrication within small studio practices and the communities related to 3D printing. Particularly looking at the possibilities and challenges that desktop 3D printing can bring to the creative practitioner.

The contextual review is divided into 5 sections: introduction to the literature related to the context of the field of creative uses of digital technology and communities around digital fabrication (1990-2017); literature related to the origins of 3D printing and relevant legislation (1980-2017); an overview of craft in relation with this research; literature related to ways of making, with a special focus on craft and a final summary.

2.1. INTRODUCTION

Modern information and communication technologies are increasing the participation level between audiences and producers to the point where the difference between them is blurred (Gauntlett, 2011; Ritzer and Jurgenson, 2010; Toffler, 1980). Some online communities are becoming hubs of development and innovation. These communities share some traits with Von Hippel´s (Hippel, 2005) definition of creative communities in which “user led innovation” emerges - where communities of users or individuals experiment and develop new products or variations of the original. Some of these communities are associated or linked to physical spaces through hacker labs or maker clubs. These clubs are dedicated to the exploration and sharing of knowledge – mainly through creative and challenging undertakings – on the topic of making and modifying software, hardware or any type of material. The activities range from knitting classes or software development to digital fabrication and rapid prototyping. Digital fabrication has gained momentum among these communities and their contribution has been critical to the increasing quality and accessibility of 3D printing.

3D printing and additive manufacturing technology

Before proceeding, it should be noted that it is common to find 3D printing defined as ‘additive manufacturing’ and vice versa. However, additive manufacturing is by far a more holistic concept than 3D printing and can be traced back to processes such as coiling clay pots or some earlier attempts at representing three dimensional geometries in the 20th century (Hoskins, 2013). 3D printing is merely one way of performing additive manufacturing. Within 3D printing there are many techniques and technologies that make it a rich and diverse process but 3D printing should not be used as a synonym for additive manufacturing. Part of the myth around 3D printing is nourished by this exchange in which both terms are used indistinctly.

In mass media, 3D printing has been touted as a fundamental change in the way we manufacture by moving from subtractive production to additive (Anderson, 2012; Berman, 2012; Zagalo and Branco, 2015). As noted, 3D printing has made additive processes more accessible, therefore, the so-called revolution upon us is that industry must attempt to redefine the mind-set required to move from one way of making to another. Yet, while it could be argued that additive manufacturing offers the opportunity to save material and time, 3D printing, for now at least, remains slow and unreliable for mass production.

Definition of 3D printing

In 2015, the Technical Committee ISO/TC 261 "Additive manufacturing" of the International Organization for Standardization (ISO) identified seven different processes under the umbrella of additive manufacturing technology known as 3D printing. Defined as: material extrusion, material jetting, binder jetting, powder bed fusion, sheet lamination, vat photo-polymerization, direct energy deposition (ISO-AMT/8, 31)[1]. For the practical part of this thesis only two of these processes were used - material extrusion and material jetting - since they are the most common techniques among desktop 3D printing machines. Per this publication they are both defined as follows:

- material extrusion: the process by which material is selectively dispensed through a nozzle or orifice.

- material jetting: the process by which droplets of building material are selectively deposited.

[1] In 2012, the committee for Additive Manufacturing technologies from the American Society for testing and Materials (ASMT) defined the same categories, however, the technical review has been withdrawn.

Material extrusion was the more commonly used process during this research. This can be referenced as Fused Deposition Modelling (FDM). A material extrusion 3D printer could be described as functioning like a hot glue gun operated by motors and controlled by a computer. Anecdotally, it can be described as a photocopier that prints a black circle. This circle is printed on several pages and, when layered, combines to create a stacked ream, then a geometry is generated by removing the white paper and leaving the stack of black circles. In fact, an FDM machine operates simply by stacking one layer of material on top of another.

Continuity with previous technologies

According to Joseph Beaman the origins of 3D printing we can arguably traced it back to photography and topography, inventors have been trying to generate and replicate geometry since the mind nineteenth century (Beaman et al., 1997). Hence, it seems relevant to consider that 3D printing is not a completely disruptive technology. It is the evolutionary descendent of other industrial processes and machining, such as CNC routing and laser cutting (ISO-AMT/8, 31). Indeed, within this thesis, I aim to demonstrate how those interested in earlier technologies are more willing to experiment with descendent digital fabrication tools. As such, this research project seeks to evidence how 3D printing expands on the family of digital fabrication processes without altering the nature of making in a digitalised environment.

3D printing, an emerging technology

Given the dissemination of digital fabrication technologies, like 3D printing, among creative communities, questions arise, such as: what are the implications of digitally-mediated working practices in the environment of traditional and contemporary creative industries?

3D printing is part of the rapid prototyping family and is one of many digital fabrication methods. Until 2005, this technology had only been accessible to high-end designers, engineers, and in some cases, students. The high price and highly skilled maintenance required limited its use. However, 3D printing and the online communities around it are creating new territory through collaboration. From sharing files and images, many have now moved into a new way of working with others in which they can share or exchange objects, all without the time and the expenditure formerly required for shipment. Even though this type of exchange could be made formerly thanks to Computer Aided Design and Computer

Aided Manufacture (CAD/CAM), 3D printing offers the chance to physically present, or 'print' whatever element or piece a practitioner is willing to share. For example, Makerbot Thingiverse is an online community formed around free sharing of knowledge and models for digital fabrication (Thingiverse.com, n.d.). In this online repository, many objects that have been collectively modified and distributed globally can be found; a behaviour that follows some of the principles of the communities of the commons and peer-to-peer production (Bauwens, 2005; Benkler, 2006; Moilanen, 2012).

Hybridisation of practices and the process of domestication

The variety of groups engaging in 3D printing includes hackers, makers, designers, artists and their associated socio-cultural relations among others, and this breadth raises questions around the emergence of hybrid practices of craft and the perception of materiality across different communities of practice.

Arguably, these recent developments in 3D printing have had an impact in current debates around practices of craft that point toward a redefinition of the term in order to subvert its current status and limitations (*Classifying and measuring the creative industries*, 2013; Dormer, 1997a). To some theorists and practitioners, notably Greenhalgh (2003) and Valentine and Follett (2010), craft is undergoing major reformations resulting in making being understood a competitive advantage within creative practices with the ability to surpass cultural barriers. There are examples in studio crafts or "fine crafts"(Risatti, 2009) that clearly show how craftspeople are using their practice to influence the perceptions of craft, particularly in contemporary discussions in which the definition of craft is central to the debates about the boundaries of craft with design and art (McCullough, 1998; Yair, 2011). The group, WeWorkInAFragileMaterial (WWIAFM)[2] are focusing their interactions on craft audiences around the debates and questions that have driven the theoretical field during the past decades. With their creative experiments, they aim to further explore and deconstruct assumptions and misinterpretations of what craft is. Some of their pieces attempt to tackle the concept of craft as the production of precious objects, the functionality of the creation, or the perception of craft being mainly about the process. Department 21 (2009) at the Royal College of Art, London, offers a complementary point of view, with this project students

[2] http://weworkinafragilematerial.com/

wanted to challenge notions of skill and authorship within the domain of craft, as well as, criticising contemporary definitions and compartmentalization of creative disciplines within HEI(Knott, 2013).

It is common[3] to find groups that thrive within the boundaries of these exploratory, at-times provocative communities. For instance, the approach of the Eindhoven Design University (EDU) encourages students to reject the label of a craft practitioner. To EDU, the relevant part of the creation is articulating the use of the end product or creative explorations combining traditional and digital processes, such as laser processes employed by Geoffrey Mann (2014) [4] and Rachel Philpott (Philpott, 2012). According to McCullough, contemporary practices of craft suggest an understanding of the discipline as an interdisciplinary activity (McCullough, 1998, p. 22). This approach enhances future development and understanding of craft and its practitioners.

The definition and identity of craft comes under scrutiny by both practitioners and wider society (MacDonald, 2005) through a reconsideration of the term itself within the current social and cultural climate (Dormer, 1997a). There are different trends (such as DIY and the Maker movement) that display a widening interest for the processes of customization and home improvement that have an influence on craft perceptions[5], and there is ample literature about the role of the amateur within the wider context of craft (Adamson, 2007a; Beegan and Atkinson, 2008; Charny et al., 2011; Dormer, 1997a; MacDonald, 2005). In many cases it is in the entrepreneurialism within these groups that innovation emerges (Bauwens, 2005; Von Hippel, 2005). However, this never appears without friction, and it is of interest how historically some innovatory practices have originated and been challenged by different groups of experts. For instance, Guttenberg's printing press of 1440 had a great impact on society and it was thought to risk the office of the scribes dedicated to writing and transcription (Fry, 2008). More recently, the industrial revolution, and, in a smaller and

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[3] For reference; Power of Making (Victoria and Albert Museum and Crafts Council (Great Britain), 2011) and(Greenhalgh, 2003, p. 3), especially relevant considering interdisciplinary practice; (Paley, 2003)

[4] http://www.mrmann.co.uk/

[5] It is interesting to note, counter technology movements as the *luddites* and the earlier French *saboteurs*.

perhaps more relevant scale - 3D printing so far and desktop publishing were both believed to pose a challenge to the handmade artefact. However, although these techniques and technologies have had an impact on craft they have not demoted it. Craft practitioners have the skill and ability to reinvent and reformulate in ways that challenge the perception of its relation to material and process as well as modern perceptions of professionalism and educational disciplines (Adamson, 2013; Greenhalgh, 2002; Jorgensen and Matthias, 2014; Lucie-Smith, 1981; Risner, 2013; Sparke, 2004; Yair et al., 2001). It is the aim of this contextual review to frame the factors that create this rich environment in which technology, tradition, education and collaboration are contested.

Digital fabrication and creativity

The rhetoric around 3D printing posits this technology at the centre of a new industrial revolution (Anderson, 2012; Berman, 2012; Johnston, 2015). It is still to be seen if 3D printing can achieve the impact that the industrial revolution had, In *Digital creativity(2015),* Gregory Sporton defends that historical comparisons of technological development tend to dismiss the underlying social context of the technologies under study- a notion often defended within STS studies (Wyatt et al., 2008). For instance, the industrial revolution was caused and created by changes at many levels, such as the displacement of labour, the de-skilling of workers, the emergence of new ways of perceiving work, the concept of alienation and generalised social turmoil (Sporton, 2015). So, although 3D printing was popularised at a time of social unrest and a global crisis (2007-2010), it seems a step too far to make such a claim. However, there is an argument for a change in which the decentralization of labour and manufacturing could be happening in relation to 3D printing. Concepts of mass customization and manufacture on demand could alter the way industrial manufacture operates today (Bauwens, 2005; Kreiss et al., 2011) in addition to new ways of creativity, authorship and distribution (Atkinson et al., 2009; Benkler, 2006; Marshall et al., 2007). If 3D printing complied with the expectations and provided unprecedented levels of customization then it is necessary to examine the processes and implications of this technology being disseminated among creative practitioners.

An initial literature study was carried out to indicate which contemporary craft practitioners working with digital technologies were in progress, and which practitioner's work had already been created that related to the research. The literature search revealed that the number of art and design practitioners experimenting with digital technologies is increasing. Evidence of this can be found in numerous exhibition venues, such as the Victoria and Albert Museum in London, and documented through the Crafts Council Make:Shift conference (Great Britain), held in 2014 and 2016[6]. Further examples of this are the publications and exhibitions of *The Power of Making*, Daniel Charny; 2011, and *Out of Hand: Materialising the digital,* Ron Labaco*; 2013.* In the Power of Making designer and amateurs were mixed as representation of the emerging digital cultures. Furthermore, with a focus on reinforcing the role of individuals in innovation there were two exhibitions; *The Future is here, curated by Alex Nelson,* at the design museum (2013). and the Science Museum; *3D printing the future*.

Several online searches were conducted in an iterative way as the practical part of the thesis evolved, for which enriching contextual reviews were required. Given the relative lack of publications within the field it was crucial to explore the British Library ETHOS theses repository, as well as conduct searches on the website of related HEI's in the field of Craft and Design. Examples of related research were found in formal MPhil and PhD research that related to practitioners, such as Drummond Masterton, Tavs Jorgensen, Katie Bunnell, John Marshall, Justin Marshall, Michael Eden, Steve Royston Brown, Rachel Philpott, Robert Ree, Irine Risner and Mingjing Lin (in progress, 2018). It is highly relevant to mention some influential research in the domain of textiles design; Lynne Murray, Jane Harris, Katherine Townsend, Danit Peleg and Ann Marie Shaw. Their exploration, and especially Bunnel, Marshall and Jorgensen's use of digital technologies in their creative practice, has formed the platform for my research.

Katie Bunnell, in 1998, carried out a practice-led research project at Grays's School of Art in Aberdeen. Her research focused on the exploration of computer technologies and environment-friendly materials, specifically on the impact of new technologies within designer-maker contexts. The integration of CAD and CAM technologies is central in the development of her inquiry as well as traditional ways of making. The format of her thesis prioritised visual communication, in order "to make explicit and transferable some of the tacit knowledge embodied in research investigations." In her research, she identified gaps in knowledge that relate to "methodologies for practice-based ceramic design

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[6] http://www.craftscouncil.org.uk/what-we-do/makeshift/

research”(Bunnell, 1998). The thesis I present here, is developed in response to this, and leads a call to create methods and ways of analysing and formalising creative collaborations within a technologized environment.

In 1999, Justin Marshall concluded a practice-based doctoral thesis at Falmouth University, titled ‘The Role and Significance of CAD/CAM Technologies in Craft and Designer-Maker Practice; with a Focus on Architectural Ceramics’. His subsequent body of work is focused on the impact of emerging digital design and fabrication tools within creative practices, specifically craftspeople and designer-maker communities. His research and approach towards collaboration is central to the development of this thesis and the ideas behind ‘bending technology’, as we read here:

> *“In terms of computer output none of what I have done is very high tech at all. I purposefully tried to keep these strategies or methods I developed quite simple so it wasn’t going to scare people into thinking ‘Well I’m a plaster maker, I’m not a computer modeller’” Justin Marshal in (Marshall, 2008b, p. 352).*

It is important to note that Justin Marshall and Katie Bunnell were part of the Autonomatic Research Group in Falmouth University (2003). Autonomatic was a research group that aimed at researching digitally mediated production and making. In 2013, Autonomatic organised *All makers now?*[7]*,* a conference that addressed questions about the relation between craft, digital fabrication and contemporary Information Communication Technologies.

Cathy Treadway (2006) conducted doctoral research aiming at the role that digital tools have in supporting creative practice. In her research, digital tools are used to enhance creative thinking. Questions related to creative expression and digital technologies are explored in her thesis (Treadaway, 2006) She further suggests the exploration of haptic interfaces in order to overcome the lack of creative expressiveness of digital technologies (Treadaway, 2007)

Michael Eden in 2008 conducted a practice-based research project at the Royal College of Art (RCA) in London, for which he investigated the role of the hand and the senses for exploring

[7] http://www.autonomatic.org.uk/allmakersnow/

materiality within the process of making. Questions pertaining to tacit knowledge, semiotics, and the notion of purpose of craft and art production were explored through digital technologies. Eden explored the dualism of hand manipulation versus digital manipulation to conclude that "Crafting a computer-generated object shares some of the same manipulative skills" (Eden, 2008).

John James Marshall in 2008, while at Robert Gordon University, Aberdeen, carried out a research project where he explored the use of computer-based tools as a way of creating new forms of hybrid practice, specifically within art and design. Marshall, being a curator, developed a framework for public exhibition. This served as a way of exploring the context at the time and helped him gain insight into emerging trends among practitioners. He developed a model of the phases that practitioners go through when integrating computer-based tools in their practices (Marshall, 2008b).

Steve Royston Brown (2009) conducted a practice-based research project at the RCA, focusing on the transformative role of digital technologies within printmaking. For him, process is a crucial part of any creative activity, and his research articulates around the concept of "thinking-through-making". His approach moves away from high-end manufacturing, and proposes a low-level approach towards the integration of complex ceramic forms with the printed image (Brown, 2010). He uses historical research and innovation studies to develop an evaluative framework, which is used to analyse iterative design activities in the studio. His research contributes to the development of versatile techniques for integrating ceramics and print works. He recently was the lead research fellow on the restoration of the Meissen Fountain at the V&A (completed in 2016), for this he used a combination of 3D printing and CNC milling.

Robert Ree (2011) at the Faculty of Information, University of Toronto, carried out an exploratory research project that approached questions concerning the rhetoric of 3D printing, the notion of digital craft and authenticity as well as social aspects pertaining to technological dissemination. He proposed to understand 3D printing as a technology in a state of flux, where its potential, as well as its actual characteristics are still being contested (Ree, 2011).

Rachel Philpott (2010) conducted a practice-based research project at the RCA. Her research developed production processes which incorporated origami, shibori, printing and fusing techniques. This led to new structural forms within textiles increasing their versatility and enabling their incorporation in engineering and design projects. The use of laser technologies in her research is exemplary, highlighting how entry-level digital fabrication technologies can enhance the practice and competitiveness within small studio practices and SMEs. Moreover, through her method of inquiry she could propose a 'non-linear' way of doing research by exploration and play.

Tavs Jorgensen is a trained ceramist; however, since moving to the United Kingdom, he has been exploring technology enhanced processes. Jorgensen has been an influential maker and researcher within this context since 2000, he defends that in order to achieve creative freedom and "human expression" (Jorgensen, 2010), practitioners should not be separate from technology, they should become one with their tools, removing the mediation of technicians and facilitators (Jorgensen, 2009a, 2009b). Jorgensen explores the role of collaboration towards innovation in more recent literature. He defends that material knowledge is paramount of further creative exploration and that technology can not bypass this knowledge. Jorgensen uses this context to defend a standpoint that moves away from techno-determinism. He embraces rapid prototyping technology as part of the process of generating media or in an intermediate state (Jorgensen and Matthias, 2014). In his conference paper *Jugstrusions: technological (in) determinism and the value of material knowledge*, he proposes an alternative view of how creative exploration of emerging technologies can be enhanced through material practice, thus giving a sense of technological *(in)determinism*. In this 2017 paper, he suggests using David Smith's notion of the *outsiders* (Smith, 2009)within technological innovation to explore manufacturing. He proposes an innovative toolset that considers; access to emerging technologies and peer support, local suppliers and contractors, material knowledge and the development of prototyping methodologies as a way of promoting material knowledge within innovation strategies (Jorgensen, 2017a).

Karen Yair et al., 2011, offer an analysis of the contribution of craft towards innovation, they suggest three stages; Stimulating innovation, Integration, dissemination and stabilisation. At the core of this stages, they identify, challenges to status quo and gaps in performance. They define as critical steps the synthesis of individual knowledge, in the second stage, and then reflection and encouragement of peripheral participation. (Yair et al., 2001) This early research hints at the perception that industrial processes can be considered as another creative tool, within the *craft-based designer* mindset as in Philpott, 2012 and Jorgensen, 2014. In more recent research she suggests that more attention needs to be given to emerging collaborative creative practice within the domain of craft and with particular attention towards technology and innovation (Yair, 2011).

In 2013 Isabelle Risner published her doctoral thesis about the impact of digital fabrication tools on UK based designer-makers. The core of her thesis is that the interaction of digital technologies and craft contributes to the development of a new *genre* of craft that she identifies as *Technepractice*. Risner defends that this is a new form of practice emerging from "*technology-enabled and hybrid networked practice and networked craft*" (Risner, 2013). Drawing from Tanya Harrod's idea of the *unobtainable* (Harrod, 2007) she argues that digital collaborations enable makers to negotiate technologies and results that would be otherwise out of reach within their practices. Risner defends that technology, can pose a challenge to productive autonomy, however, she posits *digital craft* as technology-enhanced practice in which ownership resides in the capacity for orchestrating production. *"Digital craft, depending as it does on digital modes of production which provide a framework that enable greater collective authorship and collaborative practice, tends to move making towards practices that include a range of skills, knowledges and expert contributions."*(Risner, 2013, p. 238) Collaboration plays a significant role in Risner's thesis; I use this as a departing point within my research to provide an alternative view in which technological inquiry is posited as a common practice within craft.

Additionally, ongoing research projects have been identified, some of them are highly relevant within this context. Mingjing Lin (in progress, 2018) is a current PhD candidate at the RCA, and her research explores new ways of using 3D printed textile for fashion. By using parametric design, she is exploring the possibilities of 3D printing within ornamental fashion design. Catherine Scott at the University of Ulster in Belfast (in progress, 2018), is researching the role of 3D printing as a tool and an artistic medium specifically looking at the role of workmanship within practice.

Formally published research on 3D printing technologies developed for craft practitioners and directly related to this project can be found in the work of McDonald (2013), Schunemann (2015) and Treadaway (2006, 2007). Jane Taylor and Katherine Townsend research offers further insight within the domain of craft, offering a craft based methodological approach toward digital fabrication tools.

Andy McDonald (2013) conducted a practice based-research project at Glasgow School of Art on dynamic co-design and how design methods can be used to customize digitally printed textiles. Schunemann (2015) developed paste deposition modelling techniques for craft practitioners at Brunel University. The aim of his research was to offer greater creative freedom when approaching otherwise close models of production (Schunemann, 2015)

There is a range of formally published research related to 3D printing technologies in the wider field of engineering and medicine some of this are presented in the next section, which include; Baumers et al. (2003), Bak (2003), Leong et al (2003) of special interest is the work of Robert Martin et al. (2014) where they analyse the role of 3D printing within technology and education and the work of Effrain Agilera et al. (2013) where they propose a multi-process method for creating more complex end product using 3D printing. However, the literature pertaining engineering and technical aspects of 3D printing falls beyond the scope of this research project and will not be detailed in this review.

This body of enquiry provides useful outcomes for the research the author has undertaken, because it provides a baseline for analysing the interactions with participants and offers a creative context within design and education.

Of note for this research is the limited published literature on the use of digital technologies in craft practice. A wide selection of practitioners were documented by Shillito (2013), Hoskins, (2013), Openshaw (2015), Johnston (2015) in their recent texts. They introduced a range of craft practitioners including early adopters such as Eden, Mann, Oxman et al. In total, between these three formal publications practitioners were identified as artisans working with digital technologies within their creative practices. This gives an indication of the scale of the uptake but serves only as a selected and curated theme; crossovers were apparent as Mann, Eden, Oxman were featured in all three publications and are viewed as pioneers in the field. These publications offer a contextual introduction to the practice developed under the scope of this research. However, they do not provide practical studio examples, research methods, or advice on how to incorporate 3D printing into craft practice

Shillito's text has quickly become outdated, and Hoskins, Openshaw and Johnston have plans to update and republish their texts to reflect the speed at which this field is developing.

It became apparent through this contextual review that there are many barriers to be overcome before such technologies can be widely adopted. According to the McKinsey report (2013) and contrasted with the definition of the stages of Everett Roger's diffusion of technology, 3D printers are considered to be in an "early adopters" phase, which means there is still a lot of work and experimentation required for the technology to reach the general public. Some of the current limitations include the different levels of digital skills between generations - a major issue given the demographical characteristics of makers in Scotland (Burns et al., 2012) and the lack of opportunity for hands-on experimentation (Zamora et al., 2013). Many artists and craftspeople are not digitally native and have not had access to digital technologies in addition to lacking an emotional connection with digital production (Treadaway, 2006). I have taken on the role of bridging this gap through this research, as it is described later, I organised interdisciplinary workshops and collaborations and created a research group called RAFT[8].

Alongside the emerging themes of co-creation and participation, 3D printing must be argued to be democratising the use and manufacture of plastics. Until very recently, the making, modification or repair of plastic objects was limited to industrial processes. 3D printing opens a new medium for practitioners to explore, as well as providing low-level industrial processes to a wider public with non-professional intentions. This, in addition to the fact that most of the 3D printed objects can be shared through online communication, could have an impact on worldwide distribution, not to mention influence attitudes towards materials and challenge how the value of plastic is perceived among creative communities.

Scotland offers a fascinating setting for the study of decentralised populations. Although craft is not as localised as it once was, it still maintains a close relationship with the environment. The Scottish demographics and the dispersed localisation of crafts creates a unique opportunity for identifying the potential role of digital technology as an actor in creative collaboration and the relation to the environment and identity of craft. MakeWorks[9] is a

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[8] https://www.eca.ed.ac.uk/research/raft

[9] https://make.works/

Scottish initiative at the core of a thriving creative community, their aim is to better connect creative practitioners and producers. My thesis, thrives in this environment where value, skills and workmanship are contested by contemporary communities of practice.

2.2. ORIGINS OF 3D PRINTING

There is profuse analytical and technical literature on 3D printing, as well as abundant publications from disciplines in which 3D printing has been present for almost thirty years (Levy et al., 2003). Some early adopters within industries include dentistry and some specific areas of medicine. Yet, desktop 3D printing, which is the main consideration of this research, is scarcely touched upon within the relevant literature and there exists a distinct lack of specifically published material on desktop 3D printing. Indeed, in 1983, Chuck Hull, a solar energy expert, invented stereolithography (SL) and founded 3DSystems, now one of the giants in the rapid prototyping market. As Director of Research, Paul Jacobs was surprised to observe that “that even among existing users, knowledge of the most basic relationships of this new technology is at best uncertain” (Jacobs, 1992).

Since invention, the development and diffusion of the technology has been increasing slowly. Until 2005, publications relating to 3D printing were heavily dominated by mathematical models and technical-mechanical improvements- as in; Ellerin, 2004; Pandey et al., 2003 and Thomas and Rodríguez, 2000- or the tackling of different aspects for making the technology operative and more appealing by researching surface finish and reliability such as; Ippolito et al., 1995; Lanzetta and Sachs, 2003; Pandey et al., 2003.

Early adopters

Distinctly, in dentistry and medicine the explorations were mainly linked to amplifying the range of materials, as biocompatible metals and, more recently, proteins and living cells (Bártolo et al., 2008; Leong et al., 2003). 3D printing has shown great potential for medical research, as Levy et al note: “The combination of geometrical freedom and mass customisation give an excellent prospect for medical applications (teeth, bones, supports, implants etc.,)” (Levy et al., 2003).

An example of how the technology was perceived before 2005 can be found in an article by Anna Kochan (Kochan, 1997), in which she analyses the tendencies around 3D printing, and more specifically, how the Wohlers’ report (Wohlers, 1995) demonstrates the trend of adopting 3D printing systems and foresees the lowering of machine costs by the end of the decade. Wohlers' report centres on numbers and proportional growth of the market. It suggested that we see a dramatic increase in adoption, however, from that point of view the technology would be viewed more as a means for visual evaluation and prototyping. Through this thesis, the author will examine how this prevails and sets an uncomfortable development trend that challenges a more flexible adoption, where opensource communities are left aside.

Technical literature dominated until the end of the 1990s, and, as per Wohlers' report, 3D printing was considered mainly as a method for generating evaluative prototypes. However, there was a change of direction at the beginning of the 21st century. Publications started presenting evidence of divergent practices as manufacturing end products (Bak, 2003; Singh, 2013) or as comparative studies of performance in studio practices. Mark Evans compared 'traditional' industrial design studio manufacture techniques against prototyping with an SL 3D printer, obtaining a positive result both in the manufacturing man-hours required and in subsequent performance tests (Evans and Ian Campbell, 2003). Similar trends can be identified in some other fields in which 3D printing has been more recently adopted, notably aerospace, medicine and bioengineering industries (Leong et al., 2003).

At this point, higher education teachers started seeing potential in the technology, despite the high cost of use and acquisition of the machinery. Some illustrative examples are Bøhn, 1997 and Greenhalgh, 2009. De Beer (2006) and Kroll and Artzi (2011) adopted the technology as a catalyst for design processes and as a way of enhancing communication between engineers and designers.

Potential for development, after 2005

The beginning of the 21st century brought some changes into this environment. One of the most crucial events was the expiration of one of the first 3D printing patents. This, combined with other cultural and social factors sparked what has been defined as the beginning of a 'new industrial revolution'. This revolution is argued to be based on the potential developments and mass adoption of 3D printing among other digital fabrication tools as well as changes in production and distribution of goods (Anderson, 2012; Berman, 2012).

The RepRap[10] project was founded by Dr. Adrian Bowyer in 2005, with the intention of developing self-replicating machines. By 2008, the first RepRap machine was created. According to Jones, estimates are that more than 4,500 different replicated machines existed in 2010 (Jones et al., 2011). The concept of the RepRap (self-replicating) machine emerged from the Biomimicry department at the University of Bath in England. Originally, the intention was to recreate a system that would replicate the reproductive process of nature (Jones et al., 2011). The original concept of self-replicating machines goes back to the 1940s when eminent mathematician and theorist Von Neumann coined the term. More recent advances are related to NASA in the 1980s; and an adequate overview of self-replicating research can be found in Freitas Jr. and Zachary, 1981, and Sipper, 1998. However, the self-replication of the RepRap machines remains constrained as electronic replication was - and remains - at an early stage of development. Despite this, the popularity and subsequent development of desktop 3D printers, arguably, began with Adrian Bowyer. Furthermore, the 'open source' RepRap community has extended globally and has adopted technology that contributes to improving its accessibility and reducing its cost. According to Anderson, 2012 and Berman, 2012, these factors are leading to adoption in a social strata that had no access to formerly expensive machinery, thus creating what has been called the 'third industrial revolution', a label that is being contested and challenged within 3D printing culture.

Current legislation of 3D printing and its disruptive potential

As already established, additive manufacturing is nothing new. If we talk about 3D printing as a disruptive technology, we need to look where an actual conflict of interest is evident. Besides the socio-cultural implications, patent-based industry could be facing one of the most important challenges since the industrial revolution. Digitalisation has reached other areas of intellectual property (IP) laws such as copyright, as in the case of Napster and music (Desai and Magliocca, 2014; Lee, 2012). However, despite the threat, patent-based industry has so far been out of reach of mass sharing and distribution of digital files.

Digitalisation devices, such as 3D scanning, and the supporting software, are becoming more accessible[11]. Arguably, this is contributing to the simplification of the capturing, copying,

[10] http://reprap.org/wiki/RepRap

[11] At the time of writing they can be purchased in many superstores and general supermarkets.

modification and distribution of digital objects that retain the possibility of becoming a physical copy of the original. This means that intellectual property and copyright laws could be challenged. Companies and developers may well struggle in the identification and enforcement in the relevant cases. Furthermore, we face a period of time in which "liability standards from a previous age" will be applied in many cases (Desai and Magliocca, 2014, p. 1716).

It is the concern of many 3D printing enthusiasts that in the definition of new laws to protect the intellectual property of innovators the potential of 3D printing could be hampered. So far, personal production, at least in the United States, is not considered an infringement of patents. This is because few users could currently produce patented goods at home (Desai and Magliocca, 2014, p. 1719), however, given the nature of 3D printing and 3D scanning this could be reconsidered. Limiting the use of digitisation and 3D printing could be counterproductive and limit the scope of a new wave of innovation.

Despite the current climate of change there is an apparent lack of emerging legislation, and IP laws and regulations will need to adapt to the rise of 3D printing. There are different debates emerging with concern to the possible impact 3D printing could have here. Some of the challenges to legislation could be the use of 3D printers for mending and extending the life span of consumer articles, or the replication of scarce or uncharted objects, resulting in potential black markets. As previously mentioned, there is concern among 3D printing communities about how IP laws might be put into place, for instance in comparison with DVDs and other recording and copying media. Following Aron's argument, "The music industry responded to illegal file-sharing with digital rights management (DRM) techniques that prevented a song from playing on an unauthorised device" (Aron, 2012). Yet, if the application of legislation is too rigid it would pose a threat to the development and spread of the technology.

Mass media and other informal publications have covered this from different angles. For example, in Jacob Aron's article (Aron, 2012), or the posts and white papers from Public Knowledge IP advocacy group[12] where they defend that current legislation is capable of

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[12] http://www.publicknowledge.org/Copyright-3DPrinting and http://www.publicknowledge.org/it-will-be-awesome-if-they-dont-screw-it-up

litigating with digital content as it has happened with music and video within the Digital Millenium Copyright Act[13]. Despite this, legislation is being considered under the prospect of ubiquitous 3D printing and the digital sharing of Physibles[14]. The development of up-to-date laws has been partially catalysed by projects like Defence Distributed 3D gun by Cody Wilson, in which he created a downloadable and printable plastic gun, or Cosmo Wenman's classical sculpture appropriations[15]. Wenman's 3D scans of cultural heritage represent a trend of appropriation and distribution of material culture often led by museums and other institutions. However, in his case appropriations range from playful to critical and controversial. This raises further questions about ownership and culture.

When considering these issues, one of the most salient publications is Bradshaw et al., (2010) in which they suggest that "the legal environment, in the UK at least, is surprisingly favourable towards the use of low-cost 3D printers for personal, and even in many cases commercial, purposes." However propitious that might seem, they note that, "The convergence of the Internet, digitised music and media players has had dramatic consequences for music copyright. 3D printing technology may have similar implications for artistic copyright, design rights, trademarks and patents, but in a rather more diverse legal framework." (Bradshaw et al., 2010) They conclude by giving a counter argument based on the relatively slow spread and development of the technology:

> "The most optimistic evangelist of low-cost 3D printing would probably admit that the household domestic 3D printer is years, if not decades, from widespread use. […] In the longer term, personal 3D printers may conceivably lead to radical changes in the nature of the manufacturing economy; the IP implications of such further developments have so far been imagined only in science fiction" *(Bradshaw et al., 2010).*

Without submerging into the debate of digital versus handmade, given what has been stated before it seems that law makers are prepared to understand that there is no difference

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13 The the Digital MilleniumMilenium Copyright Act is in United States the equivalent to Digital Rights Management in the United Kingdom.

14 As defined by *Pirate Bay;* http://thepiratebay.org/blog/203

15 http://cosmowenman.wordpress.com/

between what has been made physically with the materials at hand and what has been digitally modelled: “digital modelling can ‘create copyrightable expressions’” (ibid).

From a different stand point, and perhaps more relevant to this thesis, it seems that it is not emerging technologies, and especially 3D printing, that trouble IP laws. It is more that the definition of ‘Originality’ used to evaluate the creations under scrutiny is now being re-contested under the scope of a new era of digital profusion.

2.3. CRAFT

Craft identity crisis

The declassification of craft as a creative industry has probably been a side-effect of the discussions and the search for a new identity for craft where barriers between design, fine art and craft are frequently non-existent. It is widely considered that the status of craft could be at stake, or at least “traditional” perceptions of it (Dormer, 1997a; Valentine and Follett, 2010). As Grace Cochrane describes in Craft and Contemporary Theory; “[…] if we have to identify the reason for change, we would find that it may have something to do with the difficulty of agreeing on the terminology we use, and understanding how that terminology and the practices it describes, change” (Cochrane, 1997). She argues that when used in relation to working, the public perceive the word ‘craft’ in a positive manner. For instance, today it is common to find advertising that includes the words ‘craft’ or ‘crafted’ as part of its marketing strategy however mass manufactured the product may be. Dr. Sandra Alfoldy defines the process of ‘craftwashing’ as the use of the cultural meaning and values associated to craft by corporate advertising and branding (Alfoldy, 2016). From my point of view, this marks a generalised understanding of what handmade objects represent. This can be understood as cultural if approached from McCullough’s definition that “to craft is to care” (McCullough, 1998, p. 21); although arguably this is not an accurate view, rather it is a romantic one. The fact that craft is used as a tool for marketing, shows that it appeals to consumers and potentially signals a nostalgia for its processes of making; or at the very least, an enhancement of the value of objects based on laborious processes.

Craft is sometimes understood as a trade or an activity dependent on the transfer of skills from one generation to another, where tacit knowledge and tradition normally play a central role, however, contemporary approaches and discussions move away from this traditional perception. As noted earlier, there are trends that reveal how practitioners are exploring their practice to influence perceptions on craft. Some move away from the contemporary discussions in which the definition of craft is central to the debates about the boundaries of craft, design and art (McCullough, 1998) towards craft collectives and their renewed approach towards public engagement and exhibition; as in the example of the WeWorkInAFragileMaterial group (WWIAFM). Their activities aim to engage the public in the creative process, "in contrast to the image of the final product as a precious object"(Veiteberg, 2010).

WWIAFM moves away from the "modernism of the closed and finished work of art" as defined by Andreas Huyssen (1986, p. 209). An example of this point is the Design Academy Eindhoven's approach towards industrial design. Some of their students reject being labelled as craftspeople, even when many of their products are handmade. The perception they have about the influence of traditional methods and the combination of industrial manufacturing is defined by design curator Murray Moss as "Industrial Craft" (Fairs, 2007). Although these are contemporary examples, perceiving industrial development as a condition for impoverishment of the decorative arts has existed since William Morris in the 1880s (Duncan and Marlière, 1994, pp. 11–15). The Arts and Crafts nostalgic philosophy defended craft in a form of traditional purity close to previous medieval perceptions of it. This approach would be strongly criticised and refused by later movements, such as the Bauhaus School in its later iterations – although it should be noted that, originally, it had much in common with Morris through its principal Walter Gropius (1919) - and other modernist drifts in design and architecture which emerged after the First World War. Studio Craft emerged from this context, where the role of the individual maker and the prevalence of the handmade where central, according to Glen Adamson, this was conditioned by an idealization and theatricalization of the craft workshop (Adamson, 2007b).

Contemporary notions of craft seem to point to a conceptual perception in flux where interaction with audience is as relevant as the piece and practice itself. For Huyssen, the environmental awareness of the 1970s proposed a return to the "local tradition, dialects and so on". For him, these promoted the further reconsideration of modernism and technological modernization. Drawing on Foucault's post-structuralism of the "local and individual intellectual" he argues that the "postmodernity of resistance" should be embraced. That is, rather than rejecting the tensions between engagement and the mission of art, those tensions should be redefined and rediscovered in order to create a new critique and practice (Huyssen, 1986). On the other hand, Suzi Gablik in her book 'Has modernism failed?' gives an extensive account of the motivations for the reconsideration of the current materialist and consumer system. However, she argues that "object-centred" aesthetics should be reviewed (and in fact are starting to be) by a focus on relationships. Moving away from consumption, she believes art has recovered its "moral authority"(Gablik, 2004). According to Risatti (2009, p. 302) contemporary "critical objects of craft" draw on relations between different agents to move away from mind/material dualism: "Moreover, they are tied to the concepts of craft whose meanings they explore most often by using the oppositions 'function present/function absent' or 'function offered/function denied'", which seems to align with Huyssen's definition of "postmodernity of resistance".

Craft and Digital technology

As we have seen, craft has been debated in terms of practice and intention. However, when technology is added to the equation it seems to raise different questions. Technology can be debated variously in relation to craft practices, and whichever definition of craft or technology is employed it seems to affect the possibility of how they are combined:

> *"Maybe we can continue to use the word "craft" in its current problematic way, where it means so much that it almost means nothing, but it has obviously been causing problems for some time and it might be as well to find out why. I am able confidently to discuss "well-crafted", "the crafts", "crafts practice", "craftspeople" and "crafts movement", because they are to do with certain attitudes about a way of working. "Kraft" as a matter of interest, originally meant power, strength and force, and even magic, before it came to mean a "calling requiring skill and knowledge"" [definition by Shorter Oxford Dictionary] (Cochrane, 1997).*

As previously argued, craft is sometimes understood as a trade or an activity dependent on the generational transfer of skills. Yet, this could be considered a simplified view. As we have seen, contemporary hybrid practices propose that we consider different aspects of craft, such as the object created, the practice and process, the attributes of the practitioner and even the relation between the object and the creator. McCullough suggests that the product must be unique: "[craft] is not about standardized artefacts, however. It is not industrial design. It remains about the individually prepared artefact" (McCullough, 1998, p. 21). Moreover, McCullough emphasises the expertise and skill of the craftsperson, but not limited to manual dexterity (McCullough, 1998).

David Pye argues that there are two approaches to manufacture: the 'workmanship of certainty' and the 'workmanship of risk' (Pye, 1978, p. 24). The 'workmanship of certainty' would be considered as automated production where there is a standardised or homogenous output. By comparison, in the 'workmanship of risk', experimentation and learning from accidental actions is encouraged. David Pye argues that to craft is to demonstrate the highest level of commitment to a skilled task (Pye, 1978, p. 79). This is echoed in McCullough's view that "to craft is to care" (McCullough, 1998, p. 21). On the other hand, Rissati sees craft as more flexible than Pye in terms of the use of tools. Rissati posits that the concept of the 'workmanship of certainty' is erroneous as it fails to understand that certain levels of craft manufacture can be sometimes automated by the maker: "the application of the tool may be repetitive for the craft object, but the resulting object need not be if the tool is in the service of invention and the creative imagination" (Risatti, 2009, p. 170). This, arguably, opens new frontiers for experimentation with emerging tools as far as 'creative imagination' is present.

However, there is no consensus within craft theory about the potential of the use of technology; "Ubiquity: The commonest feature about technology, with its distributed knowledge, is that everything begins to look the same" (Dormer, 1997a, p. 142). In this case Dormer understands the use of technology as a means of production, rejecting the possibility of experimentation or manipulation of the process and the possibility of it generating media. In her article "Crafting Innovation" (2012), Dr Rachel Philpott offers a range of examples of how technology and craft can coexist and produce innovative processes. She explains how her deployable textiles require the use of laser cutters to accelerate the craft process, which would otherwise take too long to be viable (Philpott, 2012). Examples like this help us to understand how practitioners might embrace technology as an ally rather than as a threat, although in most cases it is more accurately seen as a hybrid practice rather than purely craft as this could conflict with notions of the handmade. This hybridity is not free of trouble, in the seminal book *The Craftsman*, Richard Sennett defines the hand made as ambivalent material culture, this is a two way dynamic where the appreciation of the material and the process of experiencing nature are considered opposite of spiritual notions of the self, moreover, he suggests that -if pragmatism is not applied- technology can be appreciated and feared at the same time, as action and experience are part of our interaction with nature;

“The man-made material object is not a neutral fact; it is a source of unease because it is man-made.” (Sennett, 2009, p. 194)

From a stand point where we adopt a wider definition of craft, and understand the mastery of a technology as an experiment-based learning process, and understand the need to develop a relation with the technology, then digital technologies could be viewed as closely related to craft:

> *“Tools and technologies have both assisted and opposed the hand throughout history; the relation is not necessarily adversarial. […] consider the example of a skilled computer graphics artisan [...] His or her hands are performing a sophisticated and unprecedented set of actions. These motions are quick, small and repetitive, as in much traditional handwork [...] the actions have a practical component, and the skill may be practiced for a livelihood and a trade identity. If we test this description against Diderot’s description of craft, almost every word fits in” (McCullough, 1998, p. 19-20).*

If we entertained this point of view, we could begin to consider software development or hacking as a form of craft. 3D printing and digital fabrication tools challenge some of the perceptions that have been outlined here as the uniqueness of the crafted objects, or the common understanding of tools within craft practices.

According to Lucie-Smith, emerging technologies often pose a challenge for practitioners; on many occasions machinery and automation have been defined as a threat to creative practices (Lucie-Smith, 1981). As new technologies emerge they modify the existing medium and the different alternatives that emerge during the creative process whilst negotiating form with a material “continuum of possibilities” (McCullough, 1998). The alteration of this range of possibilities potentially disrupts the ability of the practitioner to apply previous expertise. Furthermore, according to Gruisin and Bolter “The remediation of material practice is inseparable from the remediation of social arrangements” (Bolter, 2000, p. 357). At that lapse a need to navigate the new medium emerges for the practitioner; remediation is required in the sense of reconfiguring the relation with the medium. What Wiener called the “genealogy of the tool” (Wiener, 1988) explains how this flux can be modified by iteration. The resulting medium could be considered a new set of processes and materials once remediation is achieved. Doing so allows us to situate creative practices in a context in which technology is considered to thrive in a state of flux. We could assume that to learn about a technology whose genealogy is familiar to us would result in a much easier and more intuitive process than learning about something with completely new demands. However, this unexplored field could cause the craft practitioner to feel displaced – age could be considered critical in some cases (Loges and Jung, 2001). As stated by McCullough, the expert selects the necessary medium for each situation and defines the possibilities of the continuum by navigating the “affordances” of the medium as a type of generative system. It is the knowledge and experimental relation maintained with these systems that allows craftspeople to define their practice (McCullough, 1998).

However, to be understood as craft, a practice must be committed towards experimentation. According to David Pye experimentation is a trait of true craftsmanship where there is a commitment towards the “workmanship of risk” (Pye, 1978). That is, when the medium and the “continuum of possibilities” of a practice - be that machinery, tools or any type of media (as defined by McCullough) - allow errors to happen, it is the skilled expert the one who defines and defies the liminality between errors and successful opportunities.

Craft and 3D printing

“If indeed the digital revolution is over and the technology is no longer something new but now something old, this is a situation that is unlikely to change - indeed one day it may be considered a traditional craft in its own right” (Bottomley, 2004).

3D printing is arguably at the beginning of an industrial revolution (Anderson, 2012; Berman, 2012; Moilanen and Vadén, 2012). Lower prices and easier use of 3D printers suggests it can be a home-based alternative to everyday utilities and products. However, surveys of online maker communities (Moilanen, 2012) suggest actual use remains limited to a small homogeneous group of early adopters (Rogers, 2010). Moreover, there are many technical limitations yet to be overcome:

> *“Until now, 3D printing has largely been used by product designers and hobbyists and for a few select manufacturing applications. However, the performance of additive manufacturing machinery is improving, the range of materials is expanding, and prices (for both printers and materials) are declining rapidly - bringing 3D printing to a point where it could see rapid adoption by consumers and even for more manufacturing uses. With 3D printing, an idea can go directly from a 3D design file to a finished part or product, potentially skipping many traditional manufacturing steps. Importantly, 3D printing enables on-*

demand production, which has interesting implications for supply chains and for stocking spare parts - a major cost for manufacturers. 3D printing can also reduce the amount of material wasted in manufacturing and create objects that are difficult or impossible to produce with traditional techniques" (Manyika et al., 2013, p. 8).

3D printing is rapidly becoming popular. Aside from the obvious capacity for developing and producing one's own goods and personalization, there might be other factors driving this increase. For example, the technology offers the possibility for reconciliation with plastics. According to design historian Penny Sparke there was a regression to natural materials during the 1980s and 1990s due to a lack of bonding - of designers and consumers - with the main materials of consumerism and modernity: plastics (Sparke, 2004). Although many factors contributed to this, one of the more uninviting characteristics of the material was its low reusability and reparability. 3D printing could potentially allow for the democratisation of plastics, suggesting a range of implications from economic to ecological developments, from homemade biological plastics to grinding and reusing plastics to make new things. However, Stephen Hoskins defines the material capacities of 3D printing as limiting and incompatible with the craft skill, defending that by using 3D printing practitioners are removed from their creations (Hoskins, 2013, p. 59). Alternatively, Jonathan Openshaw (2015) introduces the concept of the post-digital artisan and openly discusses the changing role of digital technology, as well as how artisanal practice of 3D printing is a means of processing rather than an end. "Just as the microwave didn't replace the kitchen, the 3D printer is looking set to play a supporting role in the design world" (Openshaw, 2015)

Additionally, the climate for digital technologies within HEI's is changing; in January 2016, Geoffrey Mann introduced a new elective course into the postgraduate curriculum at ECA called Digital Crafting in Glass (2016). This course introduces a broad cross-section of students who are non-makers to glass through gateway tools of technology. Mann employed an innovative approach to his research-led teaching at ECA, which encourages students to explore traditional craft making techniques within the discipline of glass through the application of accessible digital fabrication processes.

Through the Digital Crafting in Glass course, students engage in practical glass workshops and Digital Fabrication Labs, as well as participating in a lecture-based programme that explores the impact of new technologies within the context of craft in the age of the post-digital artisan. A series of practical studio workshops introduce students to new tools both digital and traditional. This hands-on experience allows students use new accessible tangible and intangible technologies as gateway tools to craft and the associated traditional processes of established material-based disciplines. Research through design is a motivation to both the speaker's own independent research activities; this taught studio course was a pilot of how future research through design teaching could be utilized and put into practice to reinvigorate craft-based disciplines. Students carry out self-initiated projects exploring how these new skill-sets such as Lost PLA Casting could be integrated into their own practice (Kelly and Mann, 2017). Additionally, the MSc Material practice [16]has been created in Edinburgh College of Art, where traditional craft knowledge is encouraged as a mode of engagement within material practices and technologies.

Students, as a demographic, are particularly receptive to new technologies and can commonly be classed as Digital Natives: "a generation… who have never known a world free from personal computing and the World Wide Web" (Openshaw, 2015, p. 5). Openshaw defends that, it is the more established practitioners, from an analogue "connector generation" - those that were "brought up in the analogue but live in the digital" (ibid) – that tend to be aligned to craft materials and processes. This view is echoed in the perception that making needs to be grounded in physical skills; "In order for 'digital making' to be embedded properly within the curriculum, it must be fused with 'physical making' skills. We must end the simplistic assumptions that it is easy to design something on a computer using CAD, or that young people are no longer interested in building with their hands and using basic tools" (Commission, 2014, p. 46). Furthermore, Glenn Adamson identifies certain dependency between the two modes of making; "the ones to watch are those who see clearly that its value is only contingent - that it requires a considerable amount of buttressing to have a significant effect. While the digital does depend, ultimately, on the analogue, the contrary is true as well" (Adamson, 2013, p. 171) However, this perception is not free of techno deterministic romanticism as described by Sporton (2015). Laura Johnston (2015) describes the current context of digital creativity as a "renaissance in the art of making beautiful, bespoke objects". She goes on to introduce this new digital artisan movement in more detail: "This revolution sees the skill and vision of the craftsman once again anchored at the heart of a making process, but using new technologies to free the process from the confines of

[16] https://www.eca.ed.ac.uk/study/postgraduate/material-practice-msc

mass production and more towards on-demand manufacture and individual expression on a mass scale” (Johnston, 2015)

It is important to note that, this romantic view of emerging digital fabrication is what often leads to misleading expectations. Gregory Sporton defends that technology alone cannot be defended as a creative agent or even as a creativity enhancer (Sporton, 2015). It is in this spirit of democratisation and facilitation where many communities of practice have their roots, hacker and open source communities focus on learning and development often in the fringes of trends and technological hype (Jordan, 2008; Levy, 1984) It is within this more realistic and practical point of view that RAFT was formed in Edinburgh College of Art, the aim of RAFT is to explore contemporary ways of making within an increasingly digital environment stablishing links among practitioners, technologists, students and professionals. As creative practitioners, we engage on making and designing with a range of tools, but it’s at the core of this research group to counter technological enchantment.

Craft in Scotland

The craft community under the scope of this research is one of the least represented within the creative industries in the UK and Scotland, that is; independent craft practitioners or small enterprises. As seen in Burns et al. (2012), the geographical distribution of craftspeople in Scotland represents a challenge; in addition, most of the practitioners in this study regarded it as a secondary economic activity (Burns et al., 2012). This limits effective demographic measurement and therefore, impacts policy making and social and private investment (*Classifying and measuring the creative industries*, 2013). Some of the most relevant literature regarding this topic is presented here as a reference point for contextualising the communities under study.

According to the Scottish Executive (2012), 94% of the Scottish landscape is rural with a further 69% of it being defined as remote. 18% of the population is situated in rural environments (Burns et al., 2012, p. 77) and shares a strong feeling of community. “Craft in Scotland (including Fife) is dominated by home-based production practices, with 68% of crafts people working from their home. This […] potentially creates the conditions for socially connected and sustainable places, connecting and strengthening local communities” (Ferraro et al., 2011). Although, a direct correlation regarding the location of craft and makers has not been established there are relevant findings in the creative communities in Scotland. More than 60% of makers are female, with the dominant medium including ceramics, textiles, wood and jewellery- compared to England having a 66% and Northern Ireland 68% (McAuley and Fillis, 2004). The average age of makers in the sector is forty-five -with increasingly younger practitioners in England (McAuley and Fillis, 2004)- and although the use of social media for commercial purposes is scarce, makers recognise this is the fastest growing source of trade (Karen, 2012, p. 93). Given this average demographic it became apparent that most craft practitioners were not engaging with emerging information technologies, with my research I aim at increasing the opportunities for participation in technological experimentation within this communities.

The recent declassification of craft as a creative industry by the Department for Culture, Media, and Sport (DCMS, 2013) is one of the most challenging pieces of legislation to affect the creative industries. It has generated debate[17] and raised controversy over the way creative practices should be identified within the UK. Some of the controversy originates in the fact that previously, craft was used in an all-encompassing way and many practices were included, such as jewellery, silversmithing, and pottery. However, due to the objections raised within the industry, the DCMS promised to reassess its policy and offered to make any findings public before the end of 2013, however, the second resolution did not seem to resolve the conflict. Where their final update read as follows:

> *"We believe that many crafts workers are very clearly in creative occupations. However, in the official classifications, many of these workers are spread across a range of occupational and industrial codes which contain vastly greater numbers of obviously non-creative workers. To include these codes would not give an accurate value to the crafts sector, so we are looking at better ways to measure this contribution."(DCMS, 2013)*

A similar issue can be found in the long debate among academics and craft practitioners over what constitutes craft; how do other creative practices perceive craft, and how do they define and classify the practice (e.g., Design and Art). It has been important to understand the context of craft in Scotland to situate this research within the field of ICTs and its spread.

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[17] Mainly in online forums and blogs, see http://moregeous.wordpress.com/2013/05/08/the-uk-govt-think-craft-isnt-creative-are-they-having-a-laugh/ and http://hyperallergic.com/70731/uks-controversial-declassification-of-crafting-as-a-creative-industry/

The selection of participants for this research, was influenced by the information and issues of isolation and remoteness raised by Burns and the Scottish executive. Additionally, it helped mapping the use of Information Communication Technologies among craft practitioners in Scotland.

2.4. TECHNOLOGY AND COMMUNITIES OF PRACTICE

“Computer-mediated art in its purest form is not concerned with the production of artefact but instead with communication and interaction” (Brown, 2008)

Digital fabrication and rapid prototyping techniques have sparked new professional practices and approaches that have changed the way creative arts students develop the prototyping phase. However, increasingly sophisticated technologies and cheaper machinery are creating a change in which hobbyists and innovators are thriving in virtual and physical communities. For example, Makerbot´s Thingiverse is an online community based on the idea of free sharing of knowledge and models for digital fabrication (Hoeken and Pettis, 2013). ‘On 3D Printing’ is a blog dedicated to news related to 3D printing[18]. Shapeways[19] is an online store and community that supports 3D creativity, digital fabrication and distribution. These communities are an example of the different approaches and interactions that the reduced group of users employ to establish communication and broaden their practice. The guiding spirit behind most of these efforts is of democratising and opening the technology to a wider audience; something which has been an important consideration in the knowledge exchange and sharing of this research through applied case studies and workshops.

The role of the developers’ community and their relation to Free/Libre Open Source Software (FLOSS) and the open-source community is not accidental. The 3D printing “early adopters” are at an exploratory stage, facilitating a wave of networked creativity (Benkler, 2006). Based on Everett Roger´s technology diffusion theory (Rogers, 2010), we are now in the innovating phase- that is where a technology is being appropriated or domesticated by a reduced group of people. Hence, most participants could be typified as “techno-elites and hackers” (Coyne,

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18 “On 3D Printing - Tracking the emerging 3D Printing revolution!,” 2013

19 http://www.shapeways.com/

2007, p. 134) - practitioners who play an important role in the advance of the technology, including marginal involvement of academics and artists[20].

However, Penny Sparke suggests that the 1970s represented a critical change for design and craft. Although “practitioners were getting closer to consumers by tackling niche consumer groups” (Sparke, 2004), the relationship was still heavily influenced by the marketing sector. This approach would remain stable until the end of the 1980s. At the beginning of the 1990s different social trends and movements - for instance, ecological awareness and human rights - were generally embraced by Western societies and required further action from creative practitioners (Ewen, 2003; Madge, 1997). This awareness seemed to increase the level of interest from consumers in the production process behind consumer goods and moral and ethical concerns became part of the purchase decision mechanism, leading to “design literacy” among consumers (Heller and Vienne, 2003). That interest of the consumer in learning about the process could be an explanation for the rise in interest in manufacture leading to the emergence of DIY communities. This diffusion of design and craft knowledge, with the addition of more accessible processes are often argued to be the backbone of amateurism, the divide amateur-professional is often blurred (Adamson, 2007a, p. 141) contributing to the perception of increased professional mobility.

3D printing, consumer society and the gift

Shapeways[21] and Ponoko[22] are examples of services (or communities that offer a range of services) that use a 3D model to print a range of materials. These services are used for online marketing and distribution as well as ordering and production of bespoke gifts that can be customised. However, the activity of these manufacturers could undermine and threaten the income of craft practitioners. For Gloria Hickey and Peter Dormer in The Culture of Craft (1997) craft is, to some extent, reliant on the culture of the gift. Quoting Hickey, “It is [Craft]

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20 This is a rapidly evolving field and more projects are emerging constantly, however some worth mentioning are; Rep Rap - self-replicating rapid prototyping project, the Cronin research group in Glasgow and the Centre for Fine Print Research

21 http://www.shapeways.com/about

22 https://www.ponoko.com/

ideally suited to the conflicting needs of today's gift-giver, who strives for the personal in a consumer culture"(Hickey, 1997)

In connection to this, it seems relevant to talk about the impact of DIY culture on creative practices such as craft. The concept of the "prosumer" (Ritzer and Jurgenson, 2010; Toffler, 1980), meaning producer-consumer, captures the notion of a consumer who produces. In the 1970s, Alvin Toffler argued in *Future Shock* that the world has entered a "super-industrialised" society where manufacturing technologies are diversifying product choices (Toffler, 1980, p. 264). As seen before the 1980s and 1990s, the interest in mending and building things becomes a common hobby, giving birth to the DIY movement, from which emerged the term "makers", and this could be linked to 3D printing[23].

The customisation of a standardised product like a car, is hardly meeting traditional definitions of craft or design. Yet contemporary craft practice is increasingly about interdisciplinary approaches and exploring boundaries through new ways of working often through collaboration. However, the free exchange of artefacts reproducible with a 3D printer might influence the gift economy. As Gloria Hickey posits, the gift retains its meaningfulness when the relation between the object and the manufacturer (craft maker) can be perceived or experienced by visiting the studio.

Indeed, "Sources of inspiration, delight in materials or the making process, technical skill, professional reputation or artistic aspirations are frequently lost or misplaced in retail context where the object is divorced from its origins" (Dormer, 1997a, p. 96).

Makers and craft practitioners are redefining the way they engage with clients by using social media, whereby makers introduce behind the scenes shots of process and studio working that contextualises their practice, giving authenticity to their work. This seems to contribute to the development of the relation between craft and the digital. If the free exchange of artefacts becomes part of the online culture of the gift, it could displace craft from its status as a "limited and varied forms of production" when compared to other consumer behaviours (Dormer, 1997, p. 84). Then, the way we see, perceive and consume craft could be altered,

[23] See demographics and self–identification in 3D printing survey analysis by First Monday; http://firstmonday.org/ojs/index.php/fm/article/view/4271/3738

perhaps severing crafts' relation to the unique. On the other hand, if practitioners did decide to embrace the emerging opportunity, and use online communities and social media platforms, their material creations could be easily shared and distributed. They could be contributing to the creation of a Peer-to-Peer (P2P) system of unprecedented physicality: "P2P production methods are not a gift economy based on equal sharing, but a form of communal shareholding based on participation" (Bauwens, 2005, p. 27). To some extent ETSY, the handmade online market, has already challenged established distribution channels, but the use of 3D printing and digital files as a means of exchanging goods could deeply influence this environment. It remains to be seen how craft and the gift obtain a new status within communities of sharing and exchanging, which will probably require a different repayment system and certainly pose a challenge to the power structures formerly established when consumers visited the craft studio.

Digital culture and the internet of things

Digital fabrication technologies are becoming an empowering tool for communities to create, modify and produce objects of high quality with a relatively low cost. This emergent trend involves communities that specialise in different high skilled activities such as prototyping, fabricating and hacking; FabLabs, MakLabs and HackLabs are examples. In many cases these are self-funded independent associations with an interest in making. According to Von Hippel it is within these types of communities where "user lead innovation" emerges (Von Hippel, 2005). Furthermore, these spaces are frequently associated with "counterculture and underground movements" that can be intimately linked to digital technology innovations (Bell, 2006).

When technologies emerge, there is a need for early adopters, developers and inventors to find a way for transferring knowledge into different groups. Everett Rogers proposes in the *Theory of Innovations* (1962) that innovation follows a determined pathway, and established five steps that every idea or concept would follow to reach a full cycle of diffusion. Based on the theories of Everett Rodgers (Rogers, 1962) and the McKinsey[24] report (Manyika et al., 2013), 3D printing is thought to be in its 'early adopters and developing' phase, where

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[24] They offer a commercial and comparative analysis of the economic and social impact that 3d printing can have http://www.mckinsey.com/insights/business_technology/disruptive_technologies

innovation is still happening. There is much work required to reach the tipping point in which the technology becomes ubiquitous. Digital networks do certainly contribute to this development, according to Benkler. He posits the concept of "commons-based peer production" as an emerging distributed collaborative system (Benkler, 2006), which could support and be supported by the 3D printing community, thus modifying the digital economy. Before that, one of the most relevant points to be considered is barrier identification and confrontation of the resistance from practitioners and potential users who do not belong to early adopters' communities.

The concept of digital media will need to be reassessed once we start to see how everyday objects become digital models, which could later be transformed into home utilities such as furniture or, with time, basic electro domestics. In this respect, it is pertinent to explain the "thick description" of objects by Bruno Latour (2007). Latour suggests that through losing the materialist perception of objects we have stopped understanding objects as they are; a gathering of entities. Those aggregations - either tangible or digital - are arrangements of objects that are collated within a system or method to which he refers as technical or technology. Once the object is collated, that perception is lost and the object is just understood as a single unit. That, he argues, is an erroneous interpretation; a "thin description" of an object based on its geometrical shape, commonly expressed in a technical representation. On the other hand, a "thick description" offers information beyond that (Latour, 2007). If 3D printing starts to be understood as digital media and beyond technical representations, then we will be better able to understand what the implications of the technology are. Digital culture will become material culture and vice versa. It remains to be seen if, as Latour argues, we will recover a sense of materiality or instead keep an idealistic representation of our environment.

2.5. SUMMARY OF THE CONTEXTUAL REVIEW

Throughout this chapter, it has been possible to examine links and crossovers between emerging digital technologies and to see practical issues and visual qualities that other practitioners have encountered and employed in the field of 3D printing, such as barriers for adoption (Marshall, 1999) and accessing skills (Risner, 2013). As we have seen in the creative communities reports, digital tools remain unexplored within makers practices in the UK; "*30% of all makers used digital technology for designing, with 19% using it for making*"

(Karen, 2012, p. 38), however, younger practitioners seem to engage with digital technologies within their processes more than other makers, thus creating a divide within communities of practice.

In 2013 Hoskins, appealed for technological development within 3D printing that could create a better medium for representing tacit knowledge (Hoskins, 2013), in more recent research Jorgensen explores how technology can become a means for human expression (Jorgensen and Matthias, 2014) and how based on material skills craft practitioners can contribute to innovation (Jorgensen, 2017b). In this paper, Jorgensen suggests a model for innovation and collaboration, with my research I aim at gaining insight in the processes of technological exploration and collaboration in a 'real world' situation as has been suggested in prior research by Bunnell, 1998, and more recently, Risner, 2013. In addition to that, is important to note that collaboration through craft is now a growing field of research that has been underrepresented till very recently (Felcey et al., 2013). I specially build on Risner's suggestion that there is more research needed on technology-mediated craft relations and the need to identify how mobile craft skills and practices are within the domain of digital fabrication (Risner, 2013, p. 253; Yair and Schwarz, 2011) I link this with perceptions of professional mobility based on Beegan and Atkinson's research (Atkinson, 2010; Beegan and Atkinson, 2008).

In reviewing these reference points, it has been possible to speculate on the origins and impetus of pioneering practice in this field and to create a context for this research. This investigation is a resource for those approaching digitally-mediated collaborative works and workshops. The study of the range of artisans and practitioners working with digital technologies has been instrumental as it has afforded a clearer understanding of the field to be revealed; which has motivated and driven this research project. As I have highlighted in this summary, the departing point for my research is the need for more ´real world´ collaborative applications of digital fabrication tools and the implications that they carry for creative practitioners. I delve in this context to propose a toolkit for facilitating technologically mediated collaborations within the domain of craft. The Contextual Review suggests that this research project is relevant to the field of study and is a valid route of enquiry.

3. METHODOLOGY

The motivation behind this thesis emerged from academic literature research and personal curiosity; Originally, I wanted to influence the way craft practitioners develop a relationship with technologies that are often posed as disruptive. Hence, the influence of Participatory Action Research (PAR) in the early stages of research design was significant, PAR interventionist's program is at the core of the methodology. However, with the development of practice and research activities, I redefined my ontology of material practice and technology, as described in the theorical framework in this chapter. Furthermore, I reached a certain level of epistemological fluidity. This affected my perception of creative practice and intention to actively modify any behaviour, and in so doing sought to achieve a more neutral critical position. In chapter six, I describe this process of personal development through practice. Hereby, I present the theories and practicalities that integrate my methodolodogy. This review aims to develop a framework for theory and methods. The objectives and analysis methods of this research are presented below and are followed by a series of questions to deepen this exploration.

3.1. AIM AND RESEARCH QUESTIONS

My intention as a facilitator, observer, designer, technologist and practitioner during the workshops was to become part of the activities in a neutral way by trying not to contribute to techno-deterministic agendas (Sporton, 2015). At the same time, I strongly relied on the notion of ´knowing-in-practice´ and ´reflection in action´ (Schön, 1983). Although a plan was formulated for each workshop, I was prepared to let go and follow the activities with an open attitude, adapting and deciding according to the events and groups "in relation to the matter in hand" (Bourdieu, 1990, p. 90).

The ability to navigate situations following my sensibility and intuition (Winter, 1998) increased opportunities to question further and refine the research agenda as well as the overall design of the study. As mentioned earlier, I intended to assist others in the learning of advanced 3D modelling tools (Van den Bossche et al., 2013). This proved a challenge and was a source of frustration at some points. The decision to use low-level or simplified software gave birth to the concept of ´bending technology´. This term defines an ontological stance by which the I distanced myself from my own professional experience and habits.

3.2. THEORETICAL AND METHODOLOGICAL FRAMEWORK

I argue that technological dissemination is part of a social rite of difference- that is, when technology is used to define difference among social groups- where “rites take place […] because agents cannot afford the luxury of logical speculation” (Bourdieu, 1990, p. 96). This generates a power struggle, where actors can express resistance and complicity on different situations (Bourdieu, 1990). I believe that an analysis from a critical theory point of view would increase the division between researcher and participants. Additionally, as the power relations within the research activities are not directly subject to scrutiny, I have framed this research within a flexible constructivist stand point, where knowledge is generated *with* the participants, but a reflexive and critical point of view is maintained.

Central to the development of this methodology is the interdisciplinary understanding of ‘artistic research’ per Borghoff and Chow, 2012. Hence, the expected outcomes and objects of analysis are articulated as “artworks, installations, performances and other artistic practices” (Borghoff and Chow, 2012). Experimental 3D prints and research images were shown to participants to prompt “thinking through things” (Clarke, 2010; Ingold, 2013a; Sengers et al., 2005) and to trigger debates about social practices (Hutchinson et al., 2003). Tim Ingold refers to this as the ‘art of inquiry’, where material manipulation and thinking are intertwined (Pohjoisen kulttuuri-instituutti – Institute for Northern Culture, 2013). Dr Matt Ratto proposes an approach towards running workshops that put this thinking to collaborative practice. With Critical Making (2011), Ratto proposes to create an environment of critical reflection by connecting “technological systems and practices to critical scholarship and ideas” (Ratto, 2011).

Although this approach served as a starting point for the design of the workshop activities presented in chapter three, I decided to focus on a more flexible approach, where the capturing of participants’ perceptions was more relevant than direct engagement with scholarly ideas. Moreover, the overall methodology does not only focus on the analysis of physical outcomes. Reflection-in-action drives the line of enquiry and brings the researcher closer to the tacit dimension of practice as described by Schon:

> “Through reflection, he can surface and criticize the tacit understandings that have grown up around the repetitive experiences of a specialized practice, and can make

new sense of the situations of uncertainty or uniqueness which he may allow himself to practice” (Schön, 1983, p. 61).

Discussions while making and group activities such as analysing 3d models and 3d prints provided an opportunity for collective reflection and participation. Furthermore, my approach towards workshop faciliation follows what Schon links to music improvisation and performances where the collective act is directed by its participants, where “they are reflecting in action on the music they are collectively making and on their individual contributions to it, thinking what they are doing and, in the process, evolving their way of doing it” (Schön, 1983, p. 56).

John W. Creswell describes the actions of researchers defined by “philosophical assumptions [that] relate to ontology, epistemology, axiology, rhetoric, and methodology. Furthermore, ideological perspectives often guide such studies” (Creswell, 1998, p. 86). He argues that the

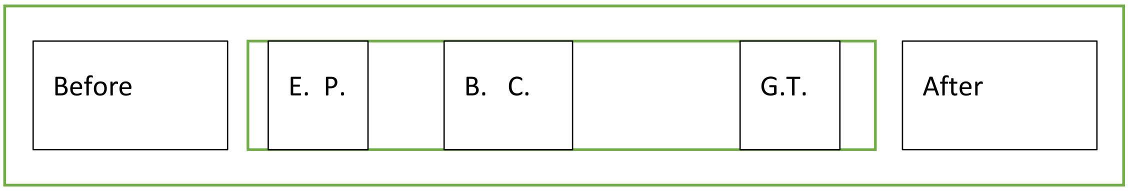

Figure 3-1 Theory and time, in order; Ethnography, Phenomenology, Biography, Case study, Grounded Theory (Creswell, 1998, p. 85)

philosophical position of a researcher is made by choice. However, he also argues that researchers often operate within a continuum of qualitative research traditions depending on when theory is created for/from the activities (Ibid).

As shown in figure 3-1, according to Creswell, the use of a qualitative research methodology influences the way the project develops depending on the point in time where theory and ideology are defined or derived from data (Creswell, 1998). Furthermore, he defends that sometimes the research paradigm is in a state of flux, where methods and epistemological stances might be reassessed (Creswell, 1998; McNiff and Whitehead, 2011). The anthropologist Marvin Harris defines the terms *emic* and *etic* as alternative perspectives to analyse cultural systems. Emic is the way an account can be given from within a culture, Etic accounts are given from an external point of view (Harris and Johnson, 2006)[25]. As described before, I had to adjust to different challenges as the project was developing, I started this research with the intention to observe and analyse the interaction between two groups of practitioners, or from an *Etic* perspective. However, at some point I became a link between technologists and craft practitioners, sometimes not knowing if I belonged to any of the groups and wondering if I was crafting or offering a technical service. I integrated myself in the culture I wanted to observe, my research agenda evolved from the point of view of a positivist observer to a phenomenologist practitioner.

3.3. HYBRID METHODS

By using hybrid methods, I gathered qualitative and quantitative data. I used; focus groups, interviews and surveys, in addition to participant follow-ups and co-creation with partners and interested practitioners. Additionally, other complementary methods were used such as primary and secondary research into the historical precedence of 3D printing.

Through this research I actively engaged in activities and dialogues with creative practitioners (from disciplines such as; jewellery, pottery, silversmithing, painting and embroidery) to develop a collaborative and exploratory practice around 3D printing. My role was to bridge the gap between the crafts peoples' skills, desktop 3D printing and the expertise required to access this technology.

3.4. PARTICIPATORY ACTION RESEARCH

Participatory action research (PAR) is a methodology based on critical analysis of social reality, with the objective of transforming it through the direct implication of its participants and the researchers (Healy, 2001; McIntyre, 2008). The production of knowledge is combined with the need to use it in a transformative manner. The population or group under study is involved in both parts. PAR offers the opportunity to discover and analyse the needs,

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[25] Emic and Etic are often simply described as insider (emic) vs outsider (etic) or wrongly described as scientific (etic) and subjective (emic). The terms are used to describe the researchers position within the culture of study. The terms were originally coined by Kenneth L. Pike (1954) and evolved from the linguistic terms phonemic and phonetic (Pike, 1967).

resources and capacities within a group. This provides the ability to design plans of action for change.

Originally, I intended to bring together two communities of practice, with the aspiration of contributing to the creation of a group of knowledge exchange between hackers, makers and traditional craft practitioners. However, barriers emerged from the outset: engaging with the local hacker community was more challenging than expected. Hence, the development of my practice and role had to be reviewed; I could no longer simply be an observer or a participant, I had to assume the role of the expert and the teacher, thus, potentially hampering the flat hierarchy and power structures providing communication among equals (Fals Borda and Anisur, 1991, p. 34). The image of the ´warm expert´ (Bakardjieva and Smith, 2001)- that is, the expert that is close to the social group of the participants - illustrates well the attitude I subsequently assumed: to be open and flexible as well as friendly and inclusive. What´s more, in most of the cases, the longitudinal collaborations transformed into friendships and critical camaraderie over time. This caused some conflict with traditional PAR paradigms where the role of the researcher is defined as an static entity (Fals Borda and Anisur, 1991; Healy, 2001).

Historical and contemporary contextual research are part of early PAR research stages. Additionally, the gathering of data and analysis should be mainly conducted by participants (Fals, 1987; Fals Borda and Anisur, 1991; Lewin, 1946; Selener and others, 1997). I conducted research to offer a comparison of technologies that emerged and influenced practices over time, as well as research about the creative communities within the scope of this project. Although, no data was gathered or produced by participants other than creating 3D models and they also did not conduct any analysis of the data beyond the revision for validation of the written accounts of the longitudinal collaborations. Hence, the researcher adopted a holistic approach that drew on PAR but responding to my needs and the ones of communities that participated in this research.

In this project, PAR was used as an overarching methodology. The key elements of the approach were focused through the following four research methods: workshops, follow-up interviews and collaborations, longitudinal collaborations (case studies) and self-reflection.

Workshops were organised with the aim of capturing perceptions about digital fabrication across Edinburgh College of Art as well as from other Scottish institutions. Workshops were used as a phenomenological approach to the issues related to 3D printing, aiming at understanding the perceptions and perspectives from participants first hand (Dukes, 1984). The workshops produced two types of data: qualitative, in the form of objects and digital files as well as discussions; and quantitative, in the form of two surveys.

I use the term ´follow-up collaborations´ to refer to further activities for inquiry after an initial engagement with a participant through the workshops. These collaborations are listed in chapter six. Some of them produced data in the form of interviews, annotations and/or digital research objects. The three most critical collaborations are presented as case studies, where there is a deep study of the relations and development of practices. The characteristics of case studies are considered interpretative (Yin, 1994), descriptive and 'bounded' (Creswell, 1998). Case studies are presented as an alternative way of engaging with practitioners. The cases studies presented here are focused on collaboration through craft and using 3D printing as a mediating technology. There was high level of interest among participants in engaging in longer projects, however, only eight out of 12 engaged beyond the stage of ´demystification´ (see section 5.3).

Self-reflection was used to explore my development as an instructor and designer. This centred my role within the project as a driving actor. Self-reflection led to an epistemological inflexion point that is explained in chapter six.

Self-reflective ethnography

The role and positioning of a researcher within the communities under study has been debated among scholars, the position of the researcher is not free of conflicts, Michael Angrosino defends that the definition of the membership from the researcher is increasingly necessary, according to Angrosino this is a secondary effect of postmodernist research trends (Angrosino, 2005). According to Sandra Acker defining the position we are at as researcher is increasingly complex in contemporary research paradigms, questioning the ability we possess to identify when we are the insider or the outsider or something in between (Acker, 2001). Even further the transitional role of the researcher can be identified as the appropriation of a different identity that challenges perceptions of the self (Kanuha, 2000). According to Adler and Adler the role and membership status defined by the researcher defines the type of information and opportunities that the researcher will get (Adler and Adler, 1987). However, I started to feel that I was creating my own community, by organising workshops around the school and starting a research group. I was documenting my own life and the one of those that were around me. According To Carolyn Ellis, autoethnography offers an opportunity to explore the self and the other within a research context where identity does not need to be contested (Ellis, 2004, p. 314) thus simplifying the definition of membership. Although, I did not choose to write a fully-fledged narrative of the self, I did use self-reflection and a diary as a way to capture and analyse the research process.

Self-reflection is present throughout this thesis. One of the main drives for exploring the connection between modes of making and digital technology emerges from my own expertise as a design engineer and product designer. ´Bending technology´ emerges from the need to re-learn skills that were practical as a design and engineering professional, but not so in the facilitation and creative exploration of technology with others. Chapter five offers an introduction to the development of my practice, as well as some of the barriers and issues raised through personal practice. My intention to work with people in relation to material is at its core a deeply personal relationship with art, this relationship has been part-frustration, part-admiration; hence there was a need to satisfy a personal desire to get closer to the material and those who manipulate it.

To get closer to my participants I had to adapt my design and engineering skills to low-level design tools, this was critical in the development of practice. Firstly, as a way of diminishing technological differences with those approaching 3D modelling and 3D printing for the first time - by putting myself through the learning experience of others, I bonded and empathised better with those approaching the processes anew. Secondly, per PAR approaches, there should be a way of blurring the lines of expertise within groups of people. By using entry level software, I positioned myself closer to those participants that had explored 3D printing before.

Self-reflection was recorded in the form of a research diary and memoranda at the end of each activity (a collection of these is presented in Appendix B), as well as analytical reviews of objects and experiments recorded throughout this research project.

Workshop design

Dr Matt Ratto proposes Critical Making as a mode of inquiry through theory-infused collaborative activities (Ratto, 2011). The workshops organised by Ratto capitalise on theoretical concepts to develop prototyping and interactions in the form of cultural probes- that is elements that unlock further insight into participants life styles and perceptions (Gaver et al., 1999). The systems developed act as props for generating discussion and engagement with material practices. Whilst bridging the theory-practice divide, which is relevant within the scope of this thesis, the aim of the workshops presented was to create a generative activity, where participants would analyse their own creations. Objects of design were presented as user cases and articulations of the technology at-hand.

3.5. QUANTITATIVE DATA

As part of the workshops, participants were asked to complete surveys before and after, as well as a recruiting survey, with the intention of offering data about potential participants. This recruiting survey had 150 respondents and was used to conceptualize part of the activities of the workshops, as well as gather information about the level of digital design skills, the disciplines, age range and professional level of participants.

As part of the process of running workshops, the researcher designed questionnaires as a way of capturing preconceptions around craft and collaboration. Additionally, they served as a way of measuring the impact of the workshop.

The data gathered through surveys was analysed using SPSS 23. Three different instruments were used: descriptive statistics, factor analysis and one-way ANOVA. Descriptive statistics were used to gain insight about the one-dimensional structures of the data - that is, categories containing one question, such as; number of participants and level of skills. One-way ANOVA was used to compare the means of different groups; this offers the possibility of combining data to contrast multidimensional data; such as seeing the relation between age and ICT fluency. Factor Analysis (FA) was conducted to explore the hidden dimensions within the data that would not otherwise be evident. The results of the FA were used as a starting point for a ´focus prompt´ analysis of the qualitative data (Kane and Trochim, 2009).

Grounded theory and thematic analysis

Considering Isabell Risner’s (2013) Research on comuniteis of practice in relation to digital fabrication I intended to approach the project using Grounded Theory (GT), however, the lack of time between rounds of data acquisition did not allow for a full analysis between workshops and interviews. Hence the iterative process and the development of thematic sample was ad hoc and based on preliminary analysis of the data; thus I felt the coding categories did not reach a satisfactory level of saturation.

3.6. INSTRUMENTS AND DATA MANAGING

Since the creative objective of collaborating with people and analysing the 3D prints created was considered central in the design of the research it was expected to be able to handle a great number of files with considerable digital size; since laser scanners and other digitalisation processes can generate very large files.

The formats that were predilected for the elaboration and storing of 3D digital models were Stereolithography (.STL) and Wavefront files (.OBJ) - an open file format commonly favoured by the open source communities of development and 3D printing. However, stereolithography has been more widely adopted among practitioners and is becoming a standardised file format for 3D model exchange for 3D printing. .STL is a portable tessellation geometry file that carries geometrical representation in the form of triangles, this reduces the weight of the files by not carrying colour or texture as other file formats would.

Here, it is important to understand the concept of watertight models. To produce a quality 3D print, a ‘healthy’ 3D model is required; this quality is achieved when the mentioned triangles (or tessellation) form a closed geometry where there is no overlapping of surfaces and openings between them. A great part of my practice time went into ensuring the quality of the collection of objects as well as teaching and learning with others how to improve and ‘heal’ digital geometries.

Technical instruments

As part of this methodology the role that specific elements and physical tools had within the research should be considered.

For this project, the tools used were:

Audio recorder: Zoom H2N, with four channel surround recording, and an Ipod internal microphone as a backup. When recording audio, it was important to consider the ratio of speech to background, since many of the focus groups were going to happen during 3D printing and/or making. With cautious time management I was able to ensure that the ratio of speech to background noise was kept within ´acceptable to good´ conditions, that is 20 decibels (dB) to 40 dB of speech over background noise (Bradley, 1986).

3D printers: at the beginning of the research, I did not have direct access to a 3D printer, so access needed to be negotiated and normally the possibilities and the localisation of the printers would be inside a technical workshop where manipulating and experimenting with the technology was not possible. Hence, I had to pursue the use of 3D printers by other means; below is a relation for printer usage and any access issues that emerged with them.

> *Dimension SST 768* professional printers, located at ECA main workshops. Access was limited to opening times (9am to 5pm, Monday to Friday) and there was no hands-on experimentation allowed, just printing advice.
>
> *MakerBot Cupcake* printer, located in the Edinburgh Hack Lab. Access was limited to a few hours per week. The Hacklab community was very supportive of ensuring it was operational.
>
> *Rep Rap tri colour,* this machine was acquired with the support of Design In Action, and was the first printer that the researcher could have full-time access to. However, the building of it and the high level of maintenance made it somewhat unreliable for workshops.
>
> *Printerbot jr. V01*, a foldable open source 3D printer. This printer was acquired for the Forensic Anthropology department of the School of Archaeology, University of Edinburgh. I developed tight bonds with the department and could freely use this printer. Together with the *Ultimaker* this would become the most used tool.
>
> *Makerbot: replicator2,* this was acquired by Design Informatics Department of ECA and was used for one of the first experiments with 3D printing, see section 5.4; Chinese whispers.
>
> *Ultimaker Original+*. Acquired with the Devolved Researcher funds awarded with the purpose of running workshops.

3D scanners

3D systems sense scanner, entry-level handheld scanner that can scan objects and rooms up to 3m by 3m.

Roland lpx 600; Workshop ECA, high-resolution laser scanner that is enclosed in a chamber. This equipment demanded a steep learning curve. For high-resolution models, settings ought to be maintained as part of the process of digitalising any model, since there are many options for configuration and slight changes produce various outputs.

Software

The range of software applications for the development of this project is too long to mention here, see chapter four for an analysis of 3D modelling software used for the workshops. The most frequently used software is presented below.

Pixologic Sculptris: intuitive and easy-to-use software, compatible with pressure-sensitive tablets. Made design activities more accessible for those with a lower level of IT fluency.

Blender: this open source all-3D software suite has some advanced modelling tools for fixing and working on 3D meshes as well as a solid file conversion system.

Autodesk Tinkercad: easy-to-use browser-based 3D design software selected since there was no download required and the design environment was straightforward to approach.

Nvivo 10: a qualitative analysis tool for generating graphical representations, analysing texts, literature and coding of interviews and focus groups.

IBM SPSS23: quantitative analysis software. An advanced research tool for the generation of statistic reports and graphic representations.

Research instruments

Here, the research instruments are considered those that help to resolve the research questions. They are presented in the tables below, the first table introduces the instruments and in which cases they were used.

Instrument	Qualitative	Quantitative	Number of respondents/ participants	Chapters/ Appendix
Surveys 1 and 2	✓	✓	150/72	4/ B
Focus groups	✓		72	4
Follow-up collaborations	✓		12	5
Interviews	✓		6	3,4,/ B
Reflective diary	✓		1	6/ B

Table 3-1, research instruments.

The table below introduces a relation of research instrument by research question.

Instrument						
Research question	**Litera-ture review**	**Surveys, quantita-tive data**	**Factor analysis**	**Thematic analysis**	**Self-re-flection**	**Collaborations**
Aim 1 sub-questions						
Identify the gaps in the literature about digital fabrication, 3D printing, craft and making	✓					

What is the use of ICT technologies within creative industries in Scotland?	✓					
What are the perceptions about 3D printing?	✓	✓	✓	✓		✓
Aim 2 sub-questions						
What are the barriers that creative practitioners encounter when using digital fabrication tools?	✓	✓		✓		✓
What are the differences between generations of users?	✓	✓				
What is the difference between collocated digital collaboration and	✓	✓	✓	✓	✓	✓

direct material manipulation?						
Aim 3 sub-questions						
What is the relation between craft practice and direct material manipulation?	✓	✓		✓	✓	✓
Does collaboration provide a better opportunity for exploring digital fabrication tools?	✓		✓	✓	✓	✓

Table 3-2, research aims and instruments.

Follow-up collaborations is the term that I have used to approach makers and practitioners who were willing to follow up the activities of the workshops by engaging in further 3D printing experimentation, this was an exciting way of capturing interests and further developing the line of inquiry.

A reflective diary was gathered through the entire period of active research (September 2012, April 2015). Only entries that are mentioned or relevant are included in Appendix B.

Data objects

Data objects are the elements of research that are considered a passive object of analysis or outputs that ought to be stored and kept under the scope of Research Data Management and the ethics pertaining to the research project:

Audio recordings of interviews, focus groups and voice memoranda.

3D models and 3D prints, stored online and in internal hard drive.

Images stored in internal hard drive and protected as sensible data.

Settings of machines and other meta files. While experimenting with the 3D printers, it became critical to store and implement a system to keep track and optimise the use of each of the printers with the aim of producing experimental prints.

Promotional and project identity designs. Although the researcher is not a graphic designer, extensive time had to be dedicated to create publicity, deliverables and content to disseminate, organise and support the development of the workshops and research collaborations.

Proposals for funding and support of experimental practices as well as research projects, courses and modules.

3.7. ETHICS AND HEALTH AND SAFETY

It is part of the university standard procedure to complete an ethics audit. In the case of this research there was no need to do an extensive ethics evaluation. So, a self-audit level one was conducted on the 2nd of April 2014 and an updated version on the 13th of April 2014, to comply with University of Edinburgh regulations. This was not easy to negotiate since there was no official position or conclusive research on potential health risks associated to the use of a 3D printer. Since the main objective was to open the 'black boxes' (Latour, 2003) of technology, I wanted to bring the 3D printers out of the workshops. On the 10th of April 2014, I met with the head officer of health and safety of ECA and when asked about the possibilities of running activities, the answer obtained was "well, [3D] printers go where they should - the workshop." (Diary entry, 10-04-2014).

To organise workshops in which hands-on experimentation could be conducted I researched relevant literature on health and safety issues. The results were not conclusive at the time of the study (April, 2014). Desktop 3D printers were defined as being as hazardous as gas cookers, however, the researchers pointed that further research was required. The review can be found in Appendix A.

3.8. SUMMARY

In this chapter, I have summarised the research paradigms and relevant methods that were considered and used throughout this PhD thesis. It is important to note that there was no lack of method but as a practice-based PhD, I took the stance that the methodology should be open ended and developmental (McNiff and Whitehead, 2011), where self-realization and improvisation play a central role (Winter, 1998). This explains why hybrid methods were the best match to develop the research at hand.

The research is carried through design practice; however, my ontological stance was in flux and my role varied across the different situations, from a service designer to servicing 3D designs and 3D prints. But what is more important is that the physical outcomes were used to prompt reflection and articulation of insights about practice and theory (Dallow, 2003; Gaver, 2012). Furthermore, the role of the community of practice that developed around the creative activities during this PhD could be articulated and defined as a group of actions where technology was being challenged and designed as a social activity (Asaro, 2000; Sporton, 2015) within the boundaries of a social ´habitus´ (Bourdieu, 1990) but approaching the domains of PAR and self-reflection.

4. PRINT3D: EXPLORATORY 3D PRINTING WORKSHOPS.

This chapter presents data gathered during a series of workshops organised with the aim of answering the research question: Within the domain and craft and making, what are the main issues and perceptions when approaching 3D printing? Further analysis is sought over what barriers exist that creative practitioners might encounter when approaching an emergent technology? And what is the role of collaboration in the learning and development of knowledge in a technology-mediated context?

In this chapter I present data collected during the workshops that were organised between March and November 2014. The workshops and the equipment used were funded by the Devolved Researcher project within Edinburgh College of Art. The name of the series of workshops and experiments to emerge from it received the name 'PRINT3D'. Beyond research and personal interests, PRINT3D aimed to bring technology closer to its social element providing greater opportunities for experimentation (Moilanen, 2012; Moilanen and Vadén, 2012; Zamora et al., 2013).

Workshops were the main mode of engagement in activities at this stage of the research. Participants were invited to return for longitudinal studies with a focus on one-to-one collaborations. Running creative workshops and focus groups was relevant since I wanted to capture general perceptions as well as observing the reactions when confronting the physicality and materiality of the technology at hand, moving away from media rhetoric. The original idea was to spark controversy to identify the differences- if any- between the different creative generations, with the aim to gain insight into their views about digital creativity and the relation to other technologies for making and crafting.

Elements of play and gamification were used in order to maintain an environment for informal learning (Cheetham and Chivers, 2005) whilst providing a safe environment for experimentation and expressing opinions (Loges and Jung, 2001). Collaboration was used as an structural support for learning, students and professionals shared the same learning experience, providing an environment for peer learning (Millis and Cottell, 1997). The rationale behind this was to promote an environment of contrast where students and early career practitioners would encounter the tradition and beliefs of others with a more developed profession, such as craft practitioners or professionals from a range of disciplines and academic fields, thus trying to build intergenerational social capital (Newman and Hatton-Yeo, 2008).

Capturing and discussing perceptions and preconceptions of practitioners and students, from a range of creative disciplines, helped developing a method for delivering and evaluating emerging digital fabrication learning skills. This approach towards 'thinking through making' offered unique insight into the cultural understanding of the technology at hand, and into the processes of rationalisation and domestication of an emerging technology (Silverstone et al., 2003). Beyond this, speculative questions and activities provided a scope for developing further experiments presented in chapter six as longitudinal collaborations.

The data presented in this chapter expose the perceptions about the technology by participants. It provides a contextual framework for the development of the collaborations presented in the subsequent chapter, and does so within a wider community of practitioners, researchers, educators and students.

Aims

- To create a 3D printing facility that brings 3D printing into a collaborative and creative exploratory context.
- To demystify 3D printing and create a culture of experimentation around digital fabrication within Edinburgh College of Art and professional circles across Scotland.
- To develop a better understanding of the processes by which emerging technologies are adopted or rejected by groups of practice.

Outcomes

- Extensive quantitative and qualitative data on the subjects pertaining to this research.
- A range of objects that portray the creative explorations.
- A critical community that is not driven by technology, but by technological curiosity.
- A guideline for deeper experimentation.

The workshops provided a launch pad to shape a community within, but not limited to, Edinburgh College of Art. From the experiences gained through running these workshops I established a network of practitioners, researchers, university staff and students relating to digital fabrication technologies that would set the basis for developing RAFT[26] - an emerging cross disciplinary research centre within The University of Edinburgh.

The process for developing the workshops of PRINT3D was iterative. The rationale behind this was to explore and refine the method of delivery, as well as develop the reflective journey as a practitioner and researcher. Reflective annotations were taken, along with photography, observation logs, audio recordings, surveys and focus groups that formed the data presented in this chapter.

The PRINT3D workshop series consisted of twelve workshops, although four more were organised in relation to other projects, including a general workshop for the Edinburgh International Festival and for the Unit of Forensic Anthropology of The University of Edinburgh[27]. Additionally, I taught three courses related to making and 3D printing. These two courses exploited the structure and learning developed through the workshops. Moreover, they offered a testing ground for some of the ideas generated during the workshops presented in this chapter that were developed through teaching, personal experiments and longitudinal collaborations. These teaching experiences were taken as additional opportunistic samples within the study (Creswell, 1998).

The structure of the workshops (PRINT3D) was designed based on previous experimentation and testing; the model of delivery evolved through iteration. The workflow and the intensity of the different activities had to be modulated to make an enjoyable yet fruitful activity. The tables below, 4-1 and 4-2, show a relation of workshops and the delivery model used in each of them. Figure 4-9 shows an overall view of research activities.

	One day workshops	Two days workshops
Model 1	A, B	Pilot (OLEUS)
Model 2	D, E, F	C
Model 3	G, H, I, J	K

Table 4-1, PRINT3D delivery models

[26] http://www.eca.ed.ac.uk/school-of-design/research/centres/%E2%96%89raft

[27] http://edinburgh-unit-fa.wixsite.com/eufa

Workshop	Theme	Round	participants	dates/2014
A	Emerging technologies	1	10	14-Mar
B	Emerging technologies	1	7	21-Mar
C	Handmade	1	8	11 and 18 Apr
D	Handmade	2	6	25-Apr
E	Handmade	2	5	02-May
F	Emerging technologies	2	8	16-May
G	Creative practice	3	3	17-Jul
H	Creative practice	3		18-Jul
I	Creative practice	4	10	Sep
J	Creative practice	4	8	16-Oct
K	Creative practice	4	5	13 and 14 Nov
EIF	general workshop	drop in		22-Aug
		Total participants	70	

Table 4-2, themes and number of participants per workshop.

As part of the project I developed a web page[28] and used social media to gain attention. The web page received significant traffic and the survey for participating was visited over five hundred times. Of those, 152 applied to participate in the workshops and seventy-two were selected to take part in the activities by considering the creative practices and age group. PRINT3D consisted of twelve workshops, although more people participated in a drop-in speed event organised for the Edinburgh International Festival. All the workshop participants were invited to return for further experimentation, with at least nine returning with queries and ideas for projects.

The workshops were organised and structured to explore and debate a range of subjects relating to 3D printing. Specifically, the questions and discussions were aimed at starting a dialogue between makers, designers and technologists that would extend beyond the focus groups at the end of each workshop. The idea behind this was to establish a critical

[28] https://print3dlaboratory.wordpress.com/

community that would thrive on the exploration of the role of emerging technologies within arts and creative practices, evaluating the definition of the handmade and the identification of the role of technology within established creative practices.

Figure 4-1, POP3D, 3D printing workshop during Edinburgh International Festival 2014, Edinburgh College of Art.

4.1. WORKSHOP DESIGN; DEVELOPING METHOD OF DELIVERY AND POLISHING RECRUITMENT.

The process of designing a workshop that satisfied both creative exploration and research needs was not evident from the beginning of the project. Firstly, I had to learn how to facilitate workshops, something I had no experience of. Secondly, the activities should be designed in a way that provided an interesting activity to draw participants in, whilst creating a rich environment to explore the research questions. Workshops and focus groups seemed to provide appropriate opportunity for the gathering of initial information and perceptions about the technology at hand, giving a special focus on personal and social learning (Brown et al., 1989; Wenger and Snyder, 2000). However, the range of possibilities and the specifics of running workshops over two days were unknown to me. Hence, the decision to organise pilot studies was made. The aim was to develop an understanding of group dynamics whilst creatively exploring an emerging technology.

Pilot studies

This first round of short workshops Intended to gain insight into the complexities of organising and facilitating creative workshops. Participants were asked to design and prepare 3D models for 3D printing. For this, they to used design tools that ranged from engineering and design software, such as, Autodesk Inventor[29] and Rhinoceros[30], to open source and browser based simplified design tools, like Tinkercad[31] and Blender[32]. This early stage experiments got 3D printed and provided insights on how complex it can be to facilitate the processes related to 3D printing when the participants are unfamiliar to 3D printing and 3D design. Participants reported on the difficulty of grasping some of the software and helped identifying some barriers relating to the use of 3D environments that would come up frequently in the subsequent workshops. One of these issues is navigating 3D dimensional space and being able to locate and connect geometries (Piegl, 2005), see Figure 4-2. In this case the participant struggled to connect the spheres to the cone and couldn't solve the issue without help. This was a departing point when designing a workflow for teaching the software to people without prior 3D design experience.

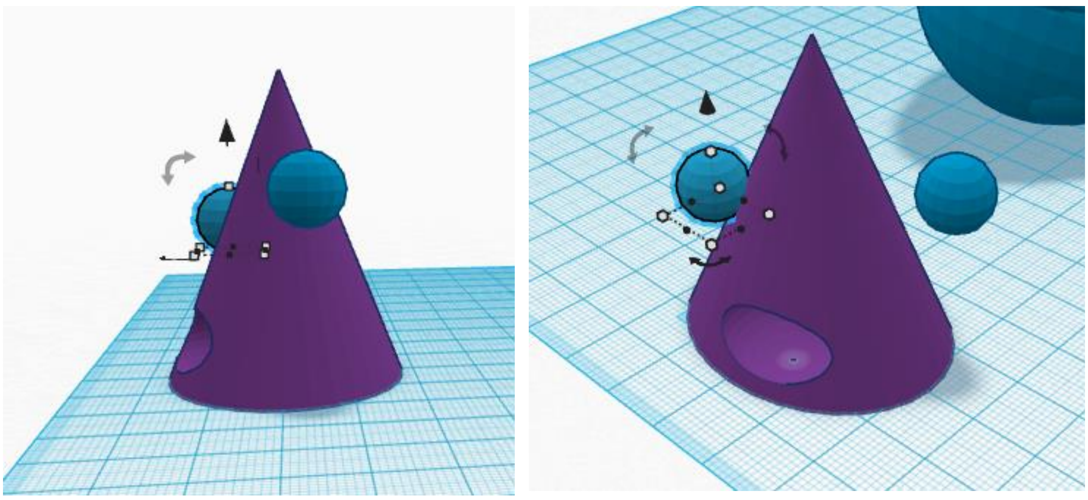

Figure 4-2-A participant struggles navigating three-dimensional space to collate geometries.

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[29] https://www.autodesk.co.uk/products/inventor/overview

[30] https://www.rhino3d.com/

[31] https://www.tinkercad.com/

[32] https://www.blender.org/

A set of four tests were designed (Table 4-3). The backing of the University reinforced the idea of using some of the software suites for design that are found in the technology laboratories. Initially, it was perceived as a great opportunity for developing the skills of participants. However, the first test evidenced the typically steep learning curve inherent in 3D design, something I had overlooked as 3D design was deeply rooted in my day to day practice as an industrial design engineer. As such, the first test subject found the concepts of 3D design highly complex, especially considering the time frame allocated within the structure of the workshops.

Test	Participants	Challenges/opportunities	Length/Comments
3D modelling with advanced design tools	Creative practitioners sourced among friends	Hard to grasp 3d software	Three hours workshop
Finding suitable software	Office colleagues	Decide between geometric or organic oriented software	Three hours workshop. Used simplified software, haptic experience versus no haptic experience
Finding suitable software 2	Scottish Documentary Institute (SDI) participants	Exploring play and humour within the activities	Four hours workshop. Only one program; Tinkercad.
Pilot workshop (OLEUS)	Selected profiles and curated group of people	How to integrate 3D printing with other creative processes?	Two days workshop. First insight into makers' views

Table 4-3-Workshop design tests.

Personal experimentation and university colleagues

The first three tests were organised with people within Edinburgh College of Art and my circle of friends and colleagues. This permitted knowledge of their backgrounds without further research being required. Three short workshops were organised, as well as a two-day workshop as a collaboration with two researchers. In the early experiments, participants were critical in the identification of a workflow for experimenting with 3D printers. It was identified that for connecting better with people coming from a range of disciplines, and potentially with no digital design experience, there was a need to find simple or easy to use 3D design software. Thus, ruling out the advanced design tools, such as ProEngineer[33], Autodesk Inventor and Rhinoceros that I used as a design and engineering professional. To get closer to entry-level design tools I started performing all the design activities with user-friendly software such as Tinkercad and Sculptris[34]. This aided understanding the limitations and opportunities that each of the software packages offered and approximated me to the needs of participants who would be learning from scratch. I offer an overview of this process in chapter five.

Pilot workshop (OLEUS)

From a serendipitous encounter, I got in contact with a colleague from Edinburgh College of Art who had some funding for running a workshop in relation to technologies and outdoor public art. We agreed to lead a joint workshop that could mutually benefit our research agendas. Outdoor Laboratory of Experimental Urban Stages 2[35] (OLEUS 2) was conceived with the idea of exploring what possibilities would be opened for participating in public art and exhibitions when using 3D printing as a medium (Figure 4-3).

[33] https://www.ptc.com/en/products/cad/pro-engineer

[34] http://pixologic.com/sculptris/

[35] https://sites.eca.ed.ac.uk/oleus/oleus2/call-oleus-2/

Figure 4-3-Outdoors pop-up exhibition by OLEUS participants. By engaging in a public environment participants explored scale and interactions with the public.

The workshop offered an initial experience on organising a workshop at the administrative level, from recruiting participants to managing catering. Additionally, it was an opportunity for testing the workflow that I had been developing for exploring 3D printing within other creative practices. Moreover, it helped understanding how to gather data and process it for research.

The data collected from this workshop was in the form of observations, photography and audio recorded focus groups and fulfilled the joint research expectations, while proving to be very useful for designing further activities. We as researchers, gained insight into the perception of 3D printing through quantitative and qualitative data as well as the perceived relation of emerging technologies within creative practices. The findings from this workshop can be found in the paper published after this workshop, *Crafting public space: Findings from an interdisciplinary outdoor workshop on 3D printing*[36]. To summarise, the conclusions extracted from that workshop were:

- More realistic view of the potential of 3D printing and digital manufacturing.
- Increased self-reported confidence levels.

[36] http://www.participations.org/Volume%2010/Issue%202/12.pdf

- Participants perceived that there could be a way of using 3D printing within their practices, especially for craft practitioners seeking to subvert the technology by modifying it, as well as making limited editions of objects to reach a wider audience.
- Several barriers were identified, such as accessibility to the technology, gatekeeping and difficulty to participate in specialist groups (Barzilai-Nahon, 2006; Canagarajah, 2002).
- Critical differences were identified between creative generations, mainly defined as an increased need to manipulate the material and a direct relation between age and computer literacy (Loges and Jung, 2001).

Some of the most influential findings within the scope of this research were voiced during informal conversations and within the focus group at the end of the day: these are presented with the rest of the data. The figure below shows the setup of this workshop.

Figure 4-4-OLEUS design stage, participants experimenting with Sculptris. Edinburgh College of Art. Image: Karl Monsen.

Software selection

Concurrently, companies were starting to put a lot of attention on the development of software and supporting processes for 3D printing; simplifying 3D design and other areas including 3D scanning and user interface. Autodesk, one of the main developers, created a family of programs for capturing, editing and processing 3D models. For my research, considering how many companies were paying attention to the potential of 3D printing, it was relevant to explore the available software to identify two or three free-to-use packages that could be utilised for the workshops. Table 4-4-Software testing for workshops, shows the evaluation conducted on the software that seemed to align with the most relevant factors for the workshops[37]. When I started running tests it became apparent that participants should be fluent in the use of computers and user interface ports such as a mouse and a keyboard, additionally it was noted that the 3D environment should not pose a challenge to be understood and used, as noted in the literature cognitive skills play an important role when approaching three dimensional environments (Dalgarno and Lee, 2010; Dickey, 2005; Huk, 2006). Given the varied background of workshop participants, it seemed relevant to assess the possibilities of using haptic devices, i.e., pressure sensitive tablets. Considering that previous research suggests that haptic experiences improve the design experience (Sallnäs et al., 2000; Shillito et al., 2001). After running the first full workshop, it was evident that 3D printing was perceived as an opportunity as far it could be used to enhance or coalesce with existing practices, hence, connectivity or the ability to interchange files (i.e., import, export or edit) between software packages became a relevant factor to consider. In the table below the score has been considered in the following way: (3) high score/very good, (2) average, (1) low score/not relevant.

Software	Usability/ Interface	Online community	Learning curve	Haptic con-nectivity	Stand-alone	IT skills needed	Connec-tivity to other software
Scultptris	3	2	3	3	3	3	1
Tinkercad	3	3	2	1	1	1	3
Sketchup	1	3	1	1	3	1	3
Autodesk 123design	3	3	2	1	2	2	3
Blender	1	3	1	2	3	1	3
OpenCAD	1	3	1	1	3	1	3
OpenSCAD	1	3	1	1	3	1	3
MeshMake	1	3	1	1	3	1	3
FreeCAD	1	2	1	1	3	1	3
Zmodeler	3	2	1	1	3	1	3

Table 4-4-Software testing for workshops

[37] The selection of software was made by testing and searching on forums, however, there is a comprehensive list of software in Wikipedia: https://en.wikipedia.org/wiki/List_of_3D_modeling_software

After conducting the tests on software, I decided to use Sculptris[38] and Tinkercad[39] for the main activities. Sculptris is an easy-to-use touch-screen compatible software that allows the user to design as though modelling with clay. Hence, simplifying the process of understanding how to create digital volumes and combine them as is common in 3D design tools. Sculptris does not use primitives, rather, it stretches or adds nodes (virtual connectors) to the digital mesh, simplifying the operations of 3D modelling. Tinkercad, offers an appealing alternative, however they represent different approaches towards 3D modelling. Sculptris is designed to create organic shapes by adding or removing geometry as if it we were applying clay, scale or dimension is not relevant when designing. On the other hand, Tinkercad is based on primitive geometries and Booleans (that is, basic geometric forms that are added or subtracted), which can present a challenge when creating organic shapes, it is designed for precision and thus offers a good platform for designing components for larger systems. This, can pose a challenge and feel more constraining to some participants, as it requires a deeper understanding of 3Dimensional environments.

Blender[40] was introduced to those participants who wanted to experiment further. Despite being a challenging program to learn, it offers a solid file conversion platform and 3D model fixing tools. It is common to create errors in the model's outer walls that distort the geometry and make them unprintable; this happens when the surfaces of the geometry are multi-layered or not joined properly. At the time of the workshops there were no accessible options for fixing 3D meshes for free. Hence, in many cases, I had to fix the files for participants. Throughout PRINT3D activities, I developed strategies when introducing software to participants that prevented such errors from occurring.

Pedagogical Rationale

The objective of the workshops was to bring together people from different disciplines, with a varied range of skills, and possibly at different stages of their professional careers. This

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[38] http://pixologic.com/sculptris/

[39] https://www.tinkercad.com/

[40] https://www.blender.org/

would provide a rich environment for encouraging discussions and promoting the challenging of established concepts and emerging tendencies in 3D printing.

This environment posed some challenges on design and facilitation, as well as on the achievement of research targets. Firstly, there would be participants with different levels of 3D design skills - from people with a lot of experience to those with none, games were used to overcome the difference in skills and confidence thus diminishing the perception of being overtly exposed in a learning situation (Cheetham and Chivers, 2005; Loges and Jung, 2001). Secondly, controversy was likely to be generated in many different aspects and the moderation of the discussion should be considered as a critical aspect of the workshops without being limited or excessively influenced by the researcher (Grudens-Schuck et al., 2004).

The workshops were organised in a way that afforded everyone an opportunity to follow a general introduction to both the context of 3D printing as well as 3D modelling. The structure of the activities encouraged personal experimentation and playfulness, thus helping the process of learning 3D design.

During the tests shown in Table 4-4 it became clear that a predominantly digital workflow could create frustration in those who are used to make things by manipulating materials (Shillito et al., 2001), hence pressure sensitive devices were provided in some workshops. Additionally, three of the workshops emphasised the role of materials - by using 3D scanners, participants could prototype with physical materials and then import them into the digital environment. This opened debate around notions of craft and its underlying relation to material manipulation, as well as creating space for play and humour.

Figure 4-5-Dog staring at half eaten chocolate bars, 2014, PLA, 2x4 cm.

4.2. PRINT3D: EXPERIMENTAL LABORATORY FOR 3D PRINTING AND DIGITAL MATERIALITY

In this section, I elaborate the first model of the collaboration framework: *bending technology* with an emphasis on group participation. In the chapter six, *bending technology* is approached and examined as a mode of interaction in a one-to-one basis.

After testing and experimenting with the technologies to develop a general understanding, I decided to apply for funding to run a series of workshops. Once the funding was granted, PRINT3D[41] was developed as an interdisciplinary experimentation laboratory on 3D printing and its supporting technologies.

The original idea was to run four two-day workshops to engage with at least forty participants in creative exploration of 3D printing. The target audience was postgraduate and research students as well as craft practitioners. The workshops would serve as a launch pad for the

[41] https://print3dlaboratory.wordpress.com/

rest of the explorations, as participants engaging in the workshops who were willing to return for further experiments, would be invited to use the machines in the laboratory (Figure 4-6). However, given the high level of response from practitioners across disciplines and the funding requisites it seemed to be more suitable to run shorter workshops with a reduced duration. This deeply influenced the way activities connected, having more workshops meant having less time for one to one experiments and at some point, short collaborations. Additionally, longitudinal collaborations and workshops were happening simultaneously which made everything connect at a deeper level, having the ideas from the workshops flowing into collaborations and experiences from deeper experiments being brought up for discussion and critique during the workshops, see Figure 4-7 for reference.

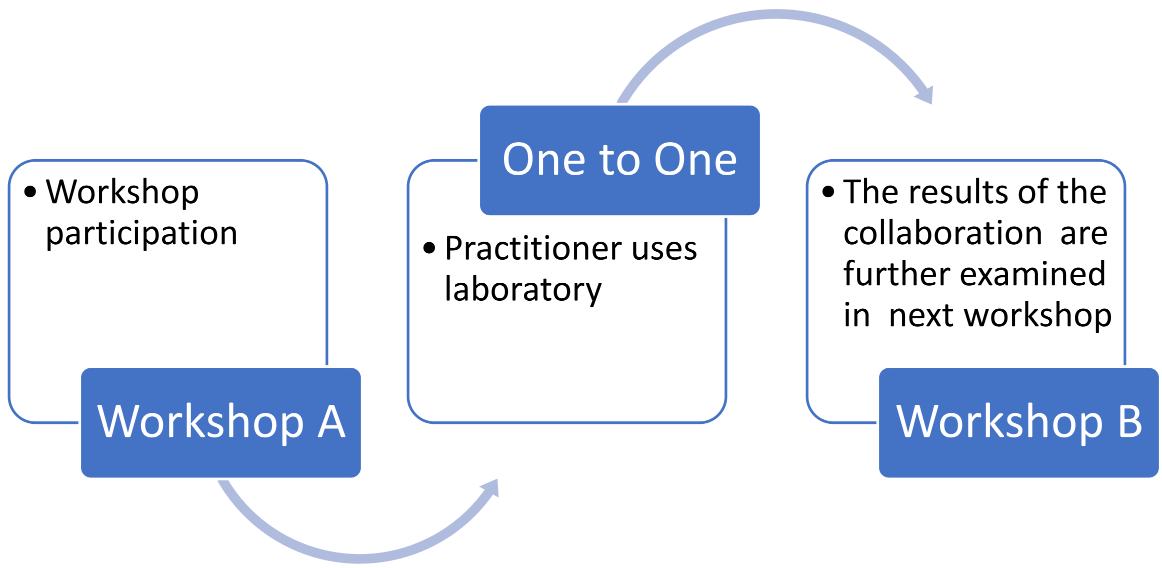


Figure 4-6-Original participation flow for PRINT3D.

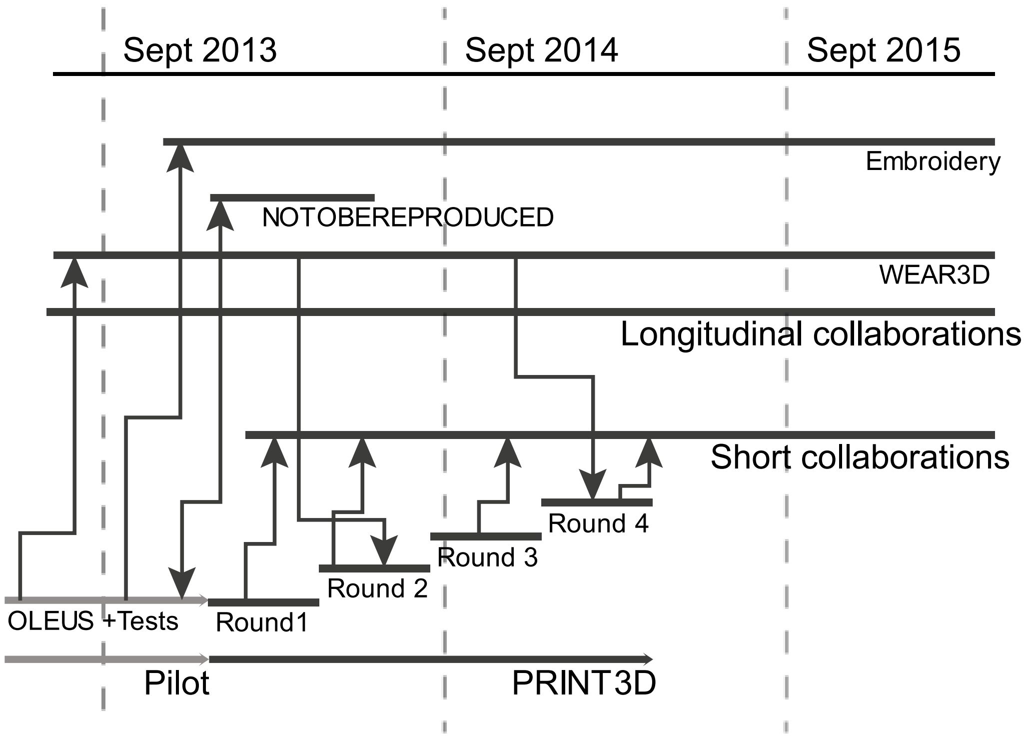


Figure 4-7-Workshops and collaborations timeline.

Drawing from the pilot workshop I identified three main conceptual areas to explore through themed workshops as well as the need to design a method for facilitating technology mediated collaboration. The main themes that structured the workshops were: the perception of technology within creative practices; the understanding of the handmade and the relation to the tool; and a creative exploration of digital processes related to 3D printing. The twelve workshops were structured in rounds per the mentioned topics, the way they were organised are presented in Table 4-2, themes and number of participants per workshop. **Error! Reference source not found.**. The themes were used as a guideline as follows:

- Perceptions of emerging technologies: in these workshops, there was an emphasis in the exploration of value and barrier identification.
- The handmade: these workshops were specifically focused on challenging the notions of the handmade by further exploring processes in which notions of physical effort and material manipulation, emotional bonding and machine-made reproductions were raised.
- Hybrid practice: in these workshops, the exploration was focused on defining workflows that could potentially adapt to different disciplines and working environments.

Recruitment of participants

The workshops were advertised through the Edinburgh College of Art mailing lists and via academic colleagues. Additionally, to guarantee the desired mix of participants in terms of age, discipline and technical experience the call had to be extended beyond the university networks. A few local craft practitioners were invited through networks and cross disciplinary activities. The workshops were promoted through Creative Scotland and Craft Scotland mailing lists. Many of the applicants were contacted thanks to a 'snowball' effect.

One of the most critical decisions was whether to invite the local hacker community and people who were already experimenting with 3D printers. Although this could have been beneficial to the activities, it was decided not to include experts in the area as it was understood that they could have had an impact on the confidence of others to voice their concerns and creative enquiries. PRINT3D aimed to create an atmosphere of play and safety to explore an emerging technology with ingenuity. Per the literature this could have challenged the smooth running of the activities and diminishing the role of peer to peer learning (Millis and Cottell, 1997). Additionally, as participants highlighted later, it was crucial to offer an opportunity in which the power structure generated by the role of experts was diminished.

Workshops model development: *Bending technology*

The development of the workshops evolved through observation, personal reflection and participant feedback. Additionally, emerging concepts through thematic analysis conducted on the recorded focus groups and discussions informed the development of the model for delivering the content of the workshops.

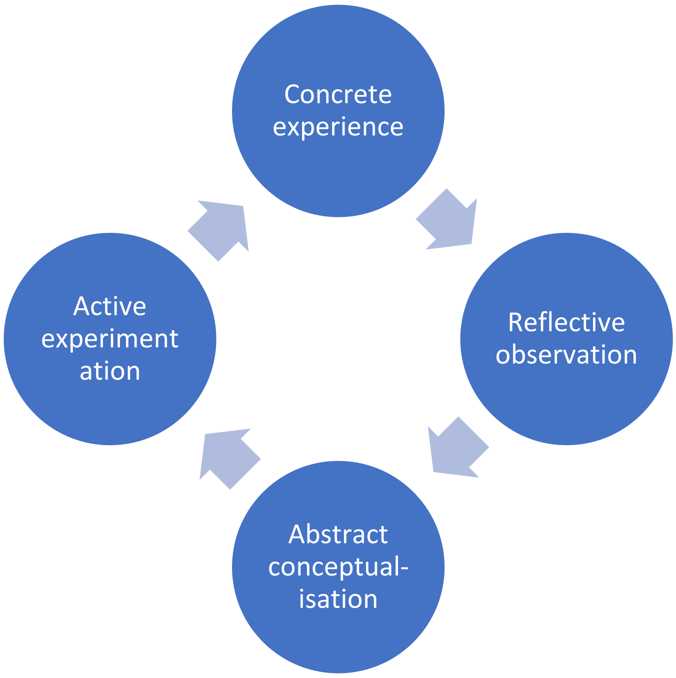


Figure 4-8-Kolb´s model of learning cycles.

Initially, my intention was to provide a range of creative workflows within each of the workshops. In this way, each participant could learn at their own pace, the model of delivery is based on David Kolb´s learning cycles theory, Figure 4-8 (Kolb, 2014). The first model of the activities is shown below in Figure 4-10. A cursory view of this chart gives the impression of design-heavy activity. This hectic program had participants exhausted at the end of the day, and the level of participation on the first focus group was low, thus hampering my ability to gather information through discussions. Not only that, participants were so tired that some voiced the need for extra breaks and a more relaxed flow of activities. In Figure 4-9, is shown the relation of activities and the geometries used to represent them in the following models.

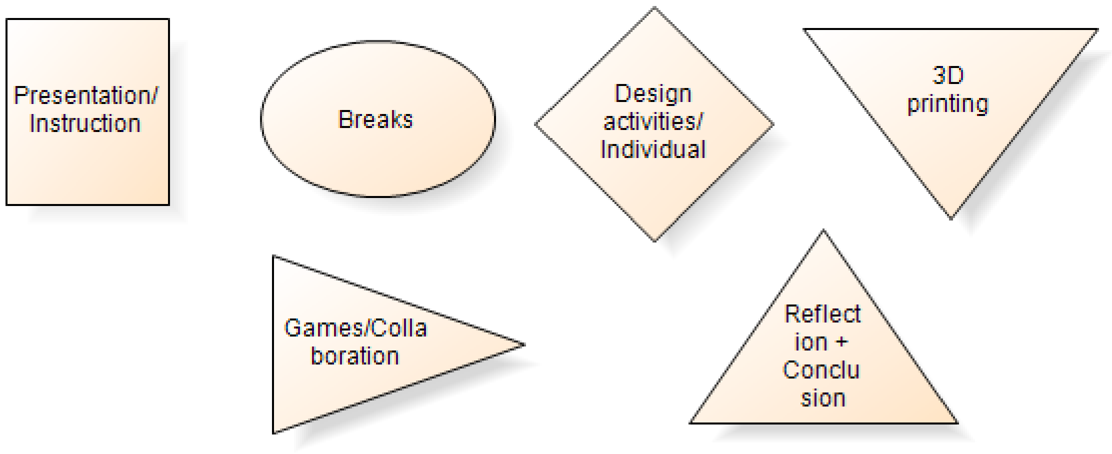


Figure 4-9-Set of activities.

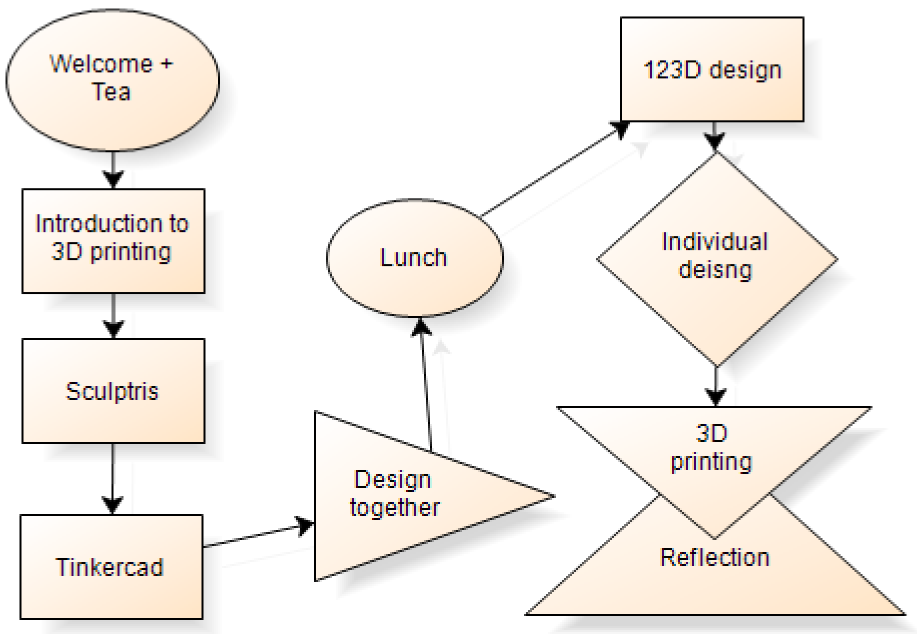


Figure 4-10-First model of delivery.

The first model (Figure 4-10) was focused on providing participants with a range of digital tools for 3D modelling that represented three different approaches when designing: organic shapes and mesh edition, geometric shapes, Boolean operation and technical drawing development. However, the excess of content delivered seemed to produce an unbalanced instruction/self-development model, and in the first workshops the time allocated for 3D printing and discussing was not sufficient. The activities commenced at 9am with an informal breakfast and introduction, this helped participants to relax and enabled me to capture some of the intentions and perceptions viva voce from participants. It was critical to capture this feedback at this stage as the activities were set to challenge their preconceptions of the technology. Then, an introduction to the context of 3D printing was given, covering social to technical aspects of 3D printing. After that the first software package was introduced. In this case, it was Sculptris as it was considered a good ice-breaker and an easy-to-use software to start experimenting with 3D modelling. However, feedback demonstrated the contrary, with participants experiencing a high level of frustration when using Sculptris. However, when tablets where used for design and connected to this software, frustrations seemed to be less acute. After a first opportunity to develop a 3D model, participants were introduced to the concept of Booleans and geometry-based design, which seemed to be a challenge for many of them. Two factors seemed to influence this, firstly the introduction of complex modelling language and jargon, and secondly a much more restrictive design environment and user interface- see Appendix B feedback section. After learning the basics of 3D modelling, there was an opportunity to interact with others through a collaborative game or challenge in which each participant started a project in TinkerCad and after three minutes of modelling the project was passed on to the next participant to modify or manipulate. This was a very dynamic way of accelerating learning as well as exploring one of the main questions of this research, collaboration within a digitally mediated environment. Gamification was part of the model from a very early stage, and it gained more weight through the development of the model and my practice. Gamification, or play, provides a comforting atmosphere when dealing with new problems or a new group of people (Flanagan, 2013; Gauntlett, 2017, 2011). These games seemed to be well received by the participants and were further developed as a means of gathering data for research.

After the games, there was an allocation of 45 minutes for lunch. Activities resumed with a third software package that is based in more advanced technical design software, 123D Design, however, in addition to the poor feedback received from participants, this software proved often problematic and slow to operate. Then, it was time for personal designing and development of models, and eventually producing a 3D print with my assistance. The workshop concluded with a focus group in which the main concepts, challenges and ideas that arose during the day were discussed.

The workshop model evolved through the course of PRINT3D, moreover, the model presented above (Figure 4-10), was only used in workshop A, since the feedback indicated that there was a need for simplifying many of the activities. Participant feedback can be viewed in appendix B. The figure below, presents the second iteration of the model of delivery.

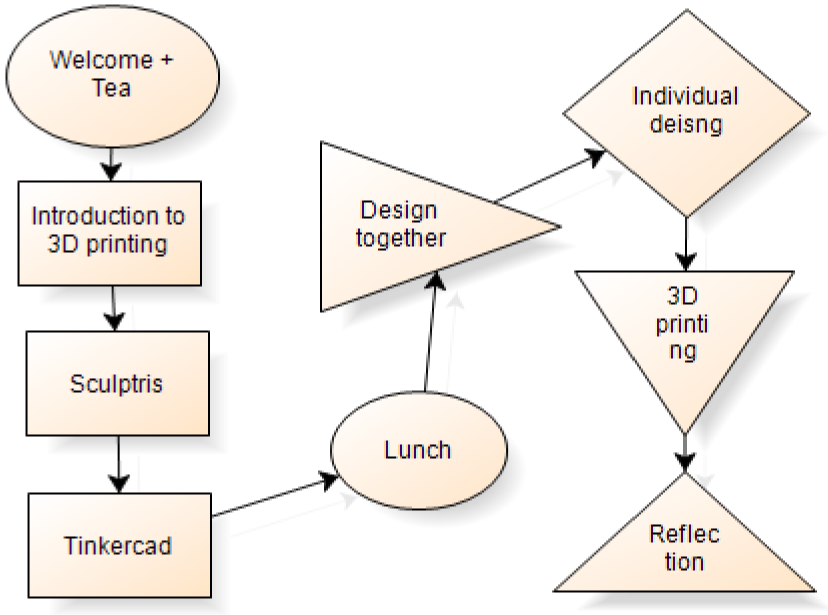


Figure 4-11-Second model of delivery, PRINT3D.

The main changes to the model were, as already stated, the reduction of software packages, and the distribution of a compressed instruction pack appendix B. This accelerated the pace of software learning and gave an opportunity for individual learning within group activities, the figure below shows the set up with three 3D printers and a participant working on her own trying to get her print right. Additionally, the introduction to 3D printing that was delivered in the form of a Power Point presentation was shortened and focused on practical examples from my own experiments and collaborations. In comparison to model 1, model 2 separated the discussion from 3D printing and in this way participants could reflect on the outcome of the process. Thus separating the stages of reflection and experimentation and getting closer to Kolb´s learning cycle (Kolb, 2014).

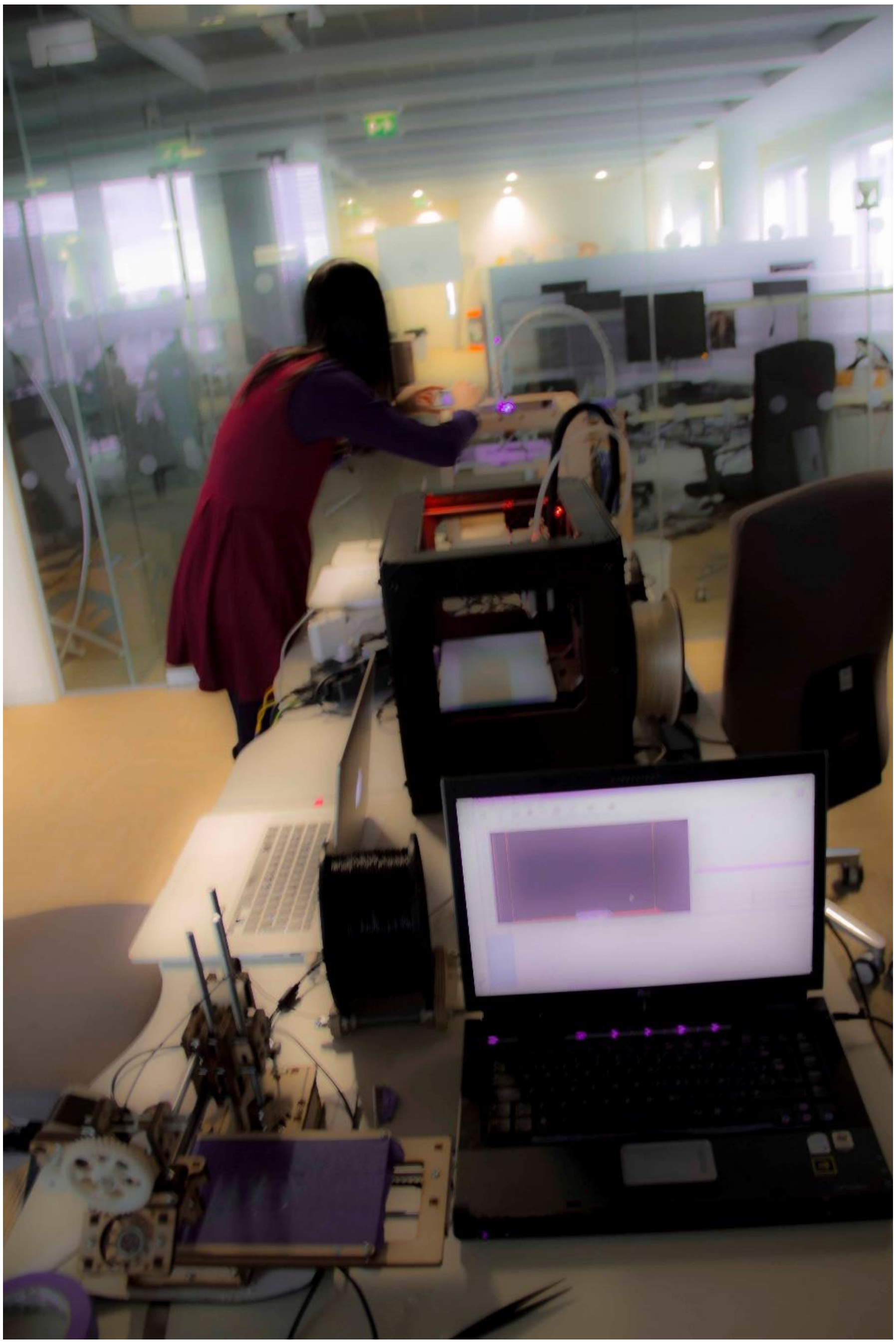


Figure 4-12-3D printers and participant recording her second attempt at improving her print.

Figure 4-13, represents the third model of workshop delivery. This model enhanced the discussions with the aim to promote a more critical approach towards making and using the technologies at hand. Opinions and perceptions surrounding the technology and other issues were shared at three points during the day - at the beginning, after learning to use the software, and at the end of the day. Often these discussions happened during design and making activities. Thus, bringing it closer to a reflection in action paradigm. Moreover, more games were added as they proved to be highly valuable as a way of exploring concepts and conflicts within digital and analogue collaboration with clay (direct material manipulation) versus collaboration in virtual environments (technology mediated tools). Additionally, playfulness boosted participants' confidence whilst experimenting and voicing opinions (see qualitative section in this chapter).

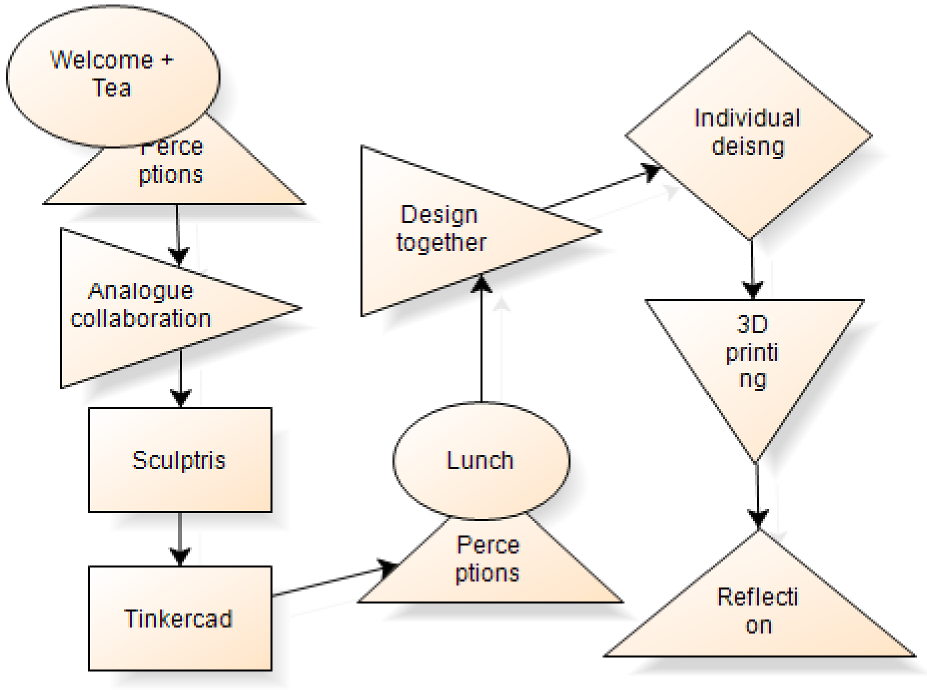


Figure 4-13-Final PRINT3D delivery model.

The culmination of PRINT3D workshops happened on the 22nd of August of 2014, during the Edinburgh International Festival, where I was proposed to run a workshop for people dropping by at Edinburgh College of Art for 3D printing. Within a period of four hours, which was divided into two two-hours slots, more than 40 participants managed to design and 3D print a digital model. The experience of running the workshops and the approach of simplifying the rhetoric and language around the process was critical to running this session, however, for the first time I felt that I had been over simplifying the activities, as I explain later in this chapter, many participants were inclined towards downloading and printing rather than designing. Although it was interesting to run this workshop, the quality and complexity of the 3D printed items was low-most of the participants created very simple objects- however, it was an interesting experiment to captivate the minds of the public to see what was printed. As well as a way of testing how fast I could teach how to create a 3D model using low-level software, as it happened in some of the other workshops, most of the prints did not go beyond trivialisation of the process, most of the objects printed were very simple keychains. Blikstein has defined the Keychain syndrome as the tendency to print or use emerging technologies that we cannot appropriate yet for elementary things, like printing keychains. Although all 40 participants managed to print something, it was a bit frustrating seeing the “keychain syndrome”(Blikstein, 2013) at play during the full day workshops and during the Edinburgh International Festival event.

Analysis and summary

The final model is therefore the result of an iterative process informed by self-reflection, observations, participant feedback and critical analysis of creative outcomes from the workshops. The level of self-reported confidence after the workshops on 3D modelling increased over time, Figure 4-14, which implies that the development of a simplified and more playful approach was more successful in terms of contributing to skill development. Additionally, the creative outcomes evolved throughout the life of PRINT3D; at the beginning, participants would often print downloaded or ready-made models, or make very simple forms and shapes, whereas in the last round of workshops, more critical and interesting objects were produced, see section 4.8 page 130. Increasingly critical approaches were voiced and more practitioners started looking at the workflow as a creative process rather than looking at it as a way of producing final pieces.

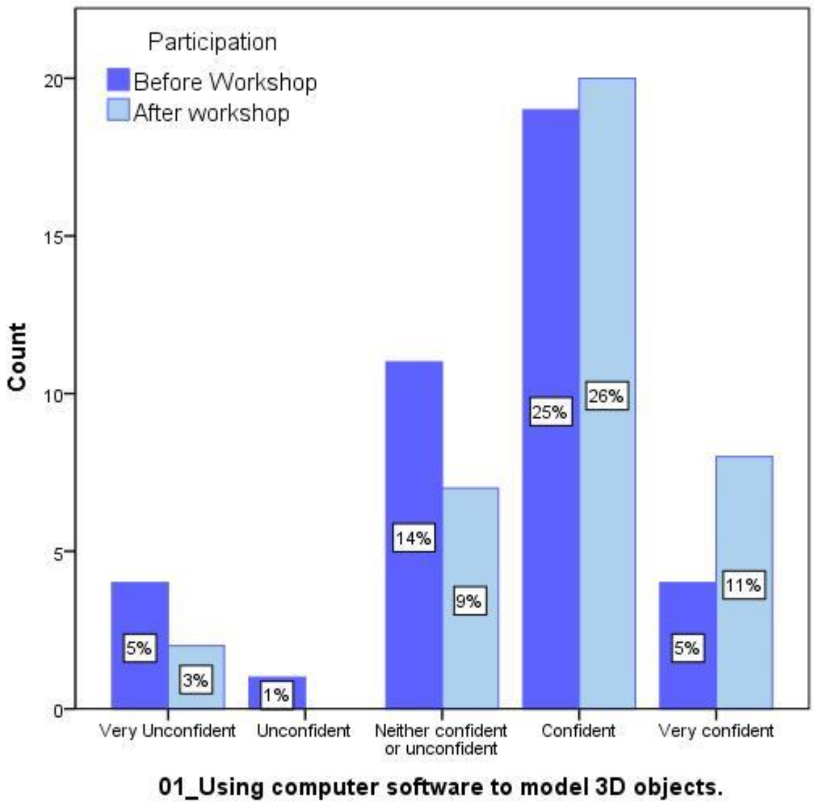


Figure 4-14-Selfreported confidence increase after participating in the workshops.

Through annotated observations and analysing workshops images (appendix B) I realised that there was an underlying process going on, varying levels of IT fluency of the participants resulted in different barriers they had to overcome to progress to the next step of the workshop. Peer-learning was common, however, most of the participants relied on my assitance to solve arising issues. Thematic analysis of the discussions as well as the analysis of the written feedback and comments led to the development of a cognitive map (Figure 4-15, below) that set the precedent for any further interaction with participants. This model was used to further develop the approach towards collaboration that I named 'bending technology'.

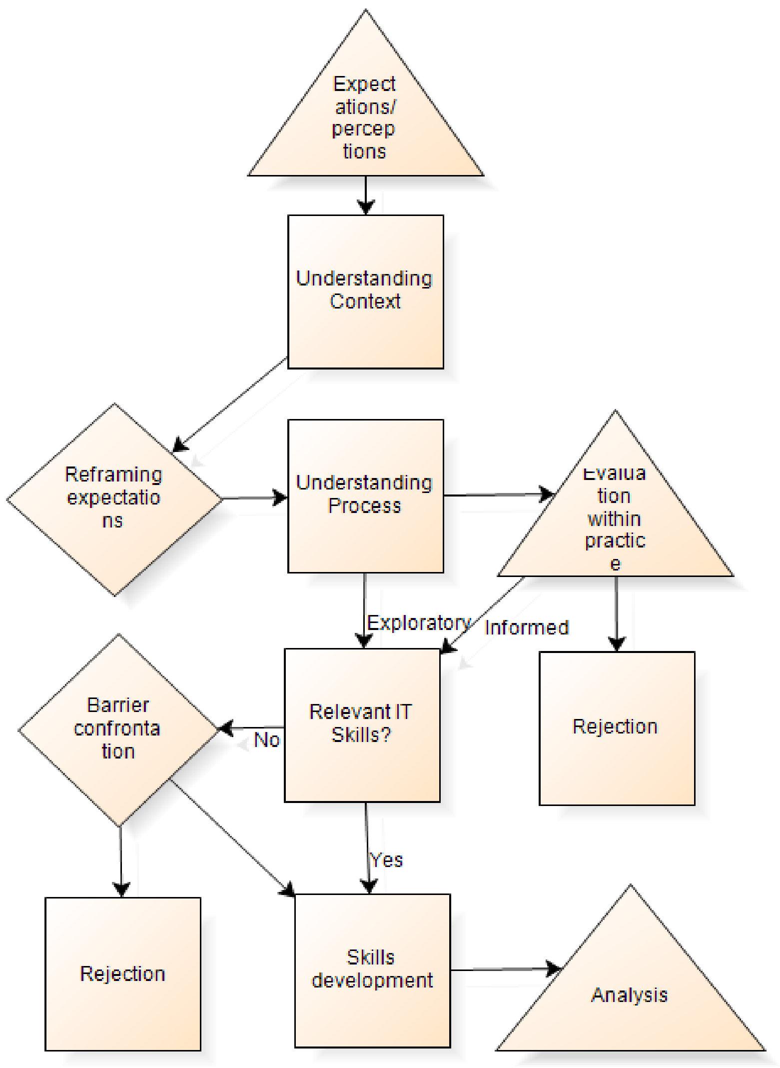


Figure 4-15-Cognitive map of evaluation of technology.

4.3. DATA COLLECTION AND ANALYSIS

During the workshops and creative collaborations, I collected notes, pictures, digital models and audio recordings. Additionally, I circulated questionnaires related to 3D printing and creative practices before and after the workshops (see Table 4-5-Questions asked to participants). This allowed for impact to be measured and feedback to be gathered from workshop participants that would not otherwise have been voiced. The answers were recorded with Likert scales and analysed using statistics and as prompts for discussions. After filing the questionnaires participants were invited to participate in an hour long informal focus group. The aim was to capture perceptions about the objects created, the experience of working with 3D printers and analysing the workflow as a creative tool. The discussions were audio recorded, transcribed and analysed using thematic analysis in Nvivo10 (Aronson, 1995). The analysis of the focus groups challenged the results from the questionnaires and informed further inquiry with longitudinal studies. The data is anonymised per their professions, age, and gender. This three factors were strongly related to their use and perception of emerging technologies.

How confident do you feel about the following questions?
01-Using computer software to model 3D objects.
02-Making physical objects with a 3D printer.
03-I believe that 3D printing will be ubiquitous within five years.
04-My creative practice lends itself well to experimenting with 3D printing.
05-I will soon incorporate 3D printing into my creative work.
How much do you agree/disagree with the following statements?
06-The workshop provided a new experience for me.
08-How confident are you working with others in a creative context.
09-The use of technology whilst making modifies positively the value of the outcome.
07-I feel more confident about using 3D printing within my creative practice than before.
10-The use of technology does not fit well within a hand making approach.
11-Technological development contributes to the creation of new hand-based practices.

12-3D printing can be used in a project/product and it can still be 'handmade'.
13-Society plays an important role on the definition of traditional hand making as a non-technologised practice.
14-It is easier to get emotionally attached to an object made by hand, than one made by a machine.
15-Working physically with the material is important to me.
16-Modelling and printing 3D objects can be considered a form of craft.
17-Unique machine-made objects threaten the status of 'traditional' craft.

Table 4-5-Questions asked to participants, before and after workshops.

4.4. RESULTS

The overall number of participants exceeded the expectations, however, not everyone took part in the research activities and some of the participants did not want their data to be used for research. A critical learning in the development of the delivery method was gained - in the first two workshops the participants reported feeling overloaded with information and activities. Although this influenced the way data was gathered thereafter, it compromised the viability and the quality of the data gathered, as most participants were too tired at the end of the day to actively participate in a discussion. Thus, the number of answers provided was limited, considering the overall number of participants. Indeed, of the seventy participants, only forty-seven completed the preliminary and posterior survey.

Questions pertaining to age and occupation were asked in the application form issued prior to participation in the workshops. The age distribution and a rough orientation of the corresponding professional categories are shown Figure 4-16. It is important to note that the students and the craft practitioners fall into two very well defined age groups, as age is an important factor when predicting digital literacy (Loges and Jung, 2001). It is important to mention that there seemed to be some overlapping between groups, and younger practitioners defined their practice as holistic and interdisciplinary (McCullough, 1998) rather than craft. Despite being well aligned with the work ethics of the other group of participants self-defined as craft practitioners.

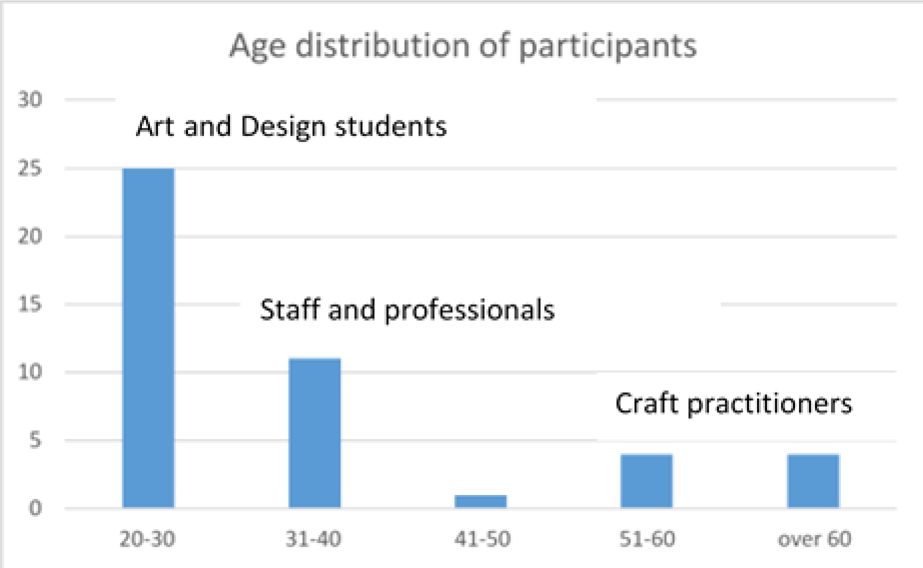


Figure 4-16-Age distribution of participants.

Statistical method

Given the size of the sample and the lack of predefined tests for evaluating material culture and 3D printing[42] I had doubts about the reliability of the data, hence the results were tested using a parametric analysis. Since the results were positive, it was concluded that parametric statistics could be used for the overall results of the survey, which is 45 respondents with a total of 82 items (or responses). This result is obtained given the fact that not all the participants in the workshop completed the questionnaires. A digital survey put to them prior to the workshops obtained a 75% response rate. A printed survey was given to them at the end of the day and the response rate was higher, but in some of the cases I preferred to focus on discussions or practical activities rather than collecting surveys. Hence, the data represents a subgroup of the overall number of participants. To achieve data consistency, I decided to include in this analysis only the data gathered from those workshops in which a survey was completed before and after, reducing even further the total number of subjects

[42] When preforming a statistical analysis, it is common to use a predefined test, they are called instruments. When conducting formal statistical studies, if the instruments to be used are not predesigned then a full validation study should be done. I acknowledge that this has not been done, hence the statistical analysis is lacking a formal validation and an error analysis.

related to this data analysis[43]. Both surveys were only completed by 64% of the participants, hence the respondent base for all graphs is 45 individuals unless stated otherwise.

In the following sections I present the statistical model, highlighting the standardisations that were required to proceed with the analysis. Firstly, graphs and results are presented to assess the impact on participant's perceptions. Secondly, an analysis of the survey and the results is presented by using a factor analysis. The aim of this was to capture the way participants were conceptualising emerging technologies and more precisely 3D printing.

Survey analysis and limitations

To simplify the task of analysing the data, I had to change the wording of the questions. In the original survey (see appendix B) there were three sections with two different Likert scales, which had to be adapted to have a coherent statistical analysis. Scale 1: strongly disagree, disagree, neither agree or disagree, agree, strongly agree. Scale 2: very unconfident, unconfident, neither unconfident nor confident, confident, very confident. To proceed with the analysis, they had to be transformed to numbers ranging from one to five. However, for the sake of simplification in the representation of the data they are presented using Scale 1; I acknowledge the grammatical conflict caused by this.

One data entry had to be changed for factor analysis as there was the only individual in the age range of 41-50. This entry was incorporated within the 51-60 age range. Since this last group had the least representation and the answers of the individual fell in-line with the views of those in the 51-60 age group. Additionally, it is important to note that this data represents a very specific population group, most of the participants were female postgraduate students, although this is in-line with the gender distribution among students and creative industry practitioners (as in; *Classifying and measuring the creative industries*, 2013). I acknowledge this gender and generational bias, and remain aware that the interpretations given to the data might be not representational of the wider creative community beyond the groups that participated in this study. The age distribution by gender of those participants who completed the surveys can be observed in the figure below.

[43] The delivery method used was very flexible and prioritised the practical activities.

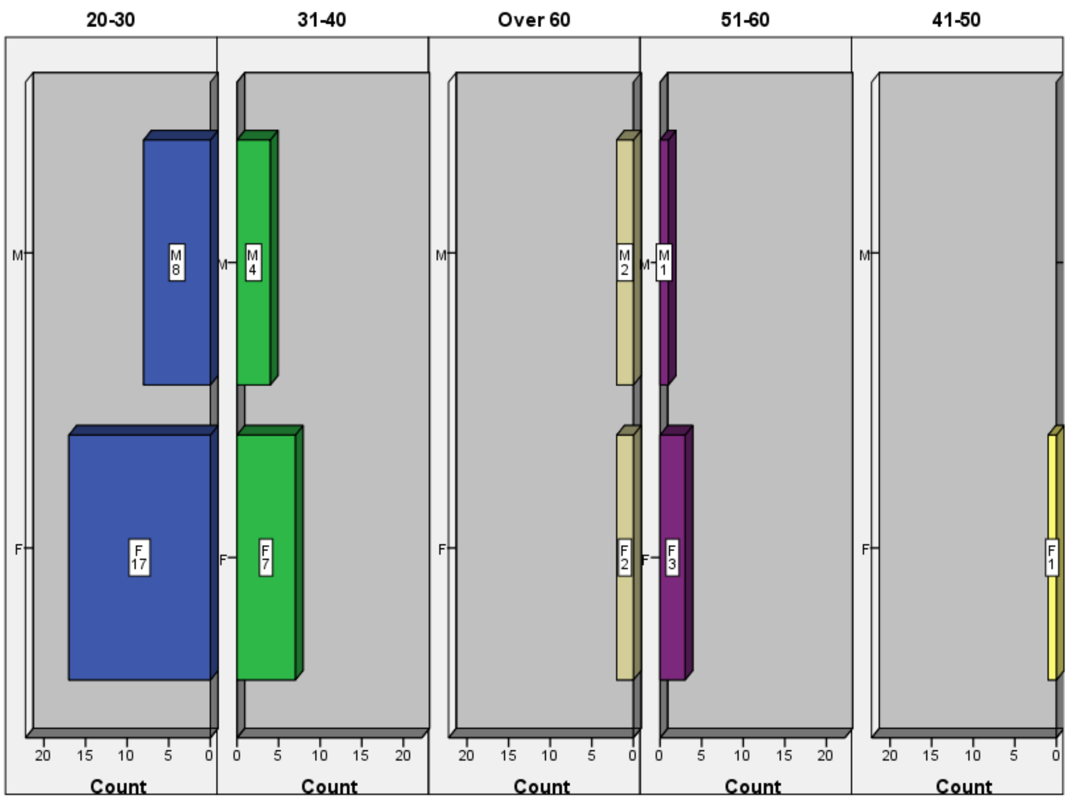


Figure 4-17-Gender distribution by age group.

Participants

Questions pertaining to gender, occupation and discipline were asked in the admission survey for the workshops, these questions were used to recruit participants. My intention was to have a group that was representational of the Scottish creative industries, according to the document 'Classifying and measuring the creative industries' (2013) and its potential members in the near future. Therefore, recruitment from within higher education institutions was relevant. Specifically, art schools and other creative circles, such as Patriot Hall[44], Out of the Blue[45], Highland Arts and Creative Scotland[46]. Additionally, the workshop call was distributed through personal networks and social media as well as universities

44 http://www.patriothallgallery.co.uk/

45 https://outoftheblue.org.uk/

46 http://www.creativescotland.com/

mailing lists. Despite the efforts, only six students were not based in Edinburgh and only two of the professionals - one from a craft discipline - were not living in the Scottish capital.

I intended to create a balanced environment were students would participate in the activities with professionals and practitioners from creative industries. The rationale behind this was to contextualise 3D printing within a wider creative and professional community throughout the career of a creative practitioner. belowFigure 4-18, below, presents the percentage of students and professionals who participated in the surveys.

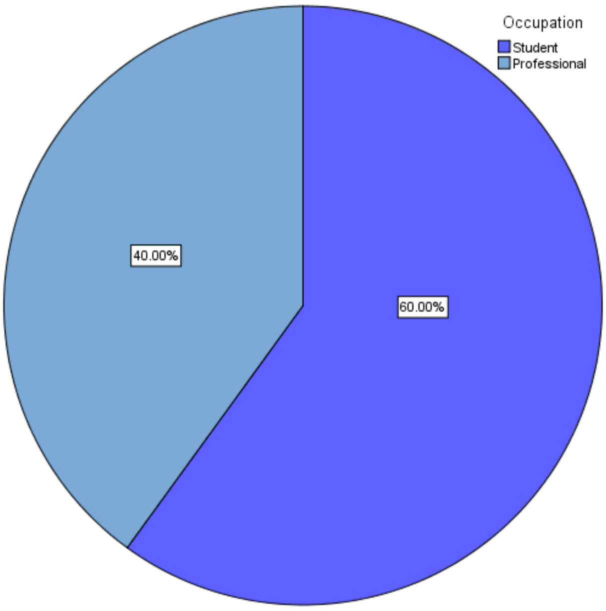


Figure 4-18-Relation of students and professionals who participated in PRINT3D.

The following graph (Figure 4-19) represents the split of participants among the different disciplines and occupation, as well as gender. It is important to note how Art and Craft have a predominantly female representation compared to the other disciplines. And that most of the participants self-defined as craft practitioners are professionals rather than students.

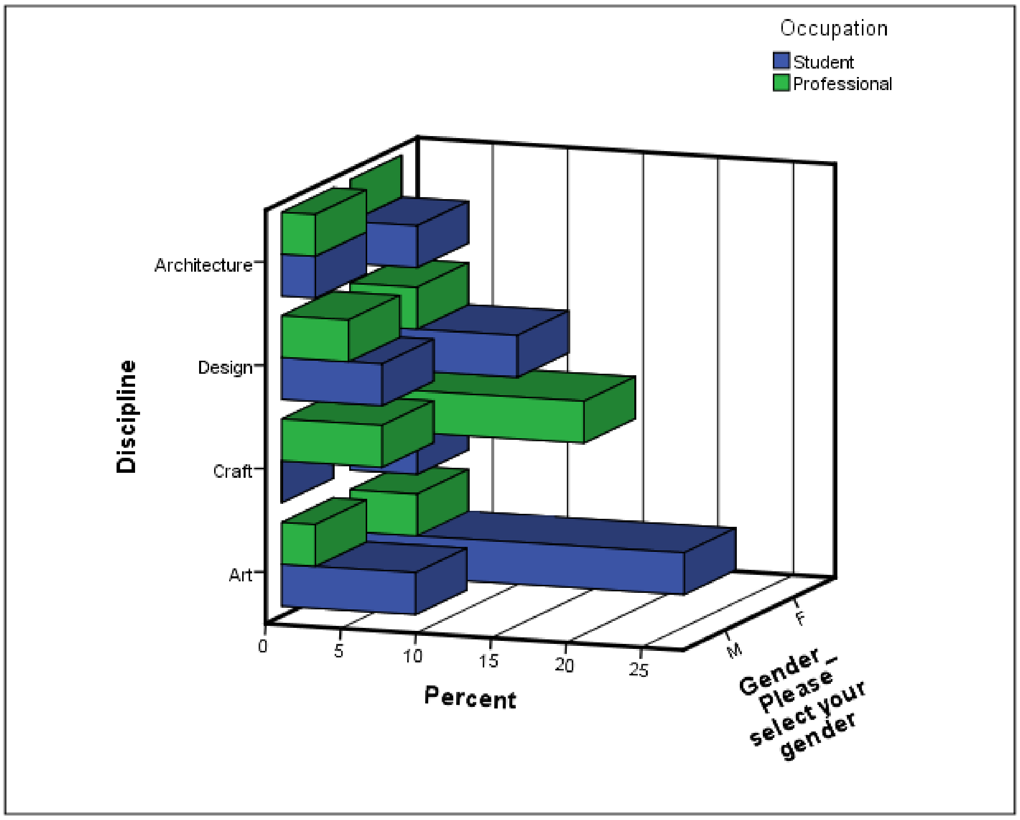


Figure 4-19-Participants by gender, discipline and occupation.

It is pertinent to highlight that some of the workshops had a strong presence of students - and as seen in Figure 4-21, workshops J, C and K were only formed by students – additionally Figure 4-20 shows the distribution of disciplines by workshop. These two factors are important when considering the development of the workshop model and when analysing the qualitative data, the perceptions expressed by groups of younger participants diverge from those in which fields and generations are mixed (Newman and Hatton-Yeo, 2008) To the point in which, in workshops J and K there was no disagreement in the perception of digital tools being part of an everyday toolkit. As I explore later, differences in these generational perceptions consisted of the appreciation of the relation to materials and the levels of computer literacy.

Younger practitioners were more avid on developing computer based skills and perceived working with a computer as a form of craft more readily than older participants. In addition to encountering less technical barriers when learning to use 3D design software.

> *[the workshop and 3D modelling] "has helped demystifying, for instance the barrier older people was perceiving, now I see it in a completely different way, now I*

perceive it as fun, if it is more like a chore… then you don't use it. Now I can see quite happily how this could quite easily interact with my practice." Jeweller. 50-60 years old.

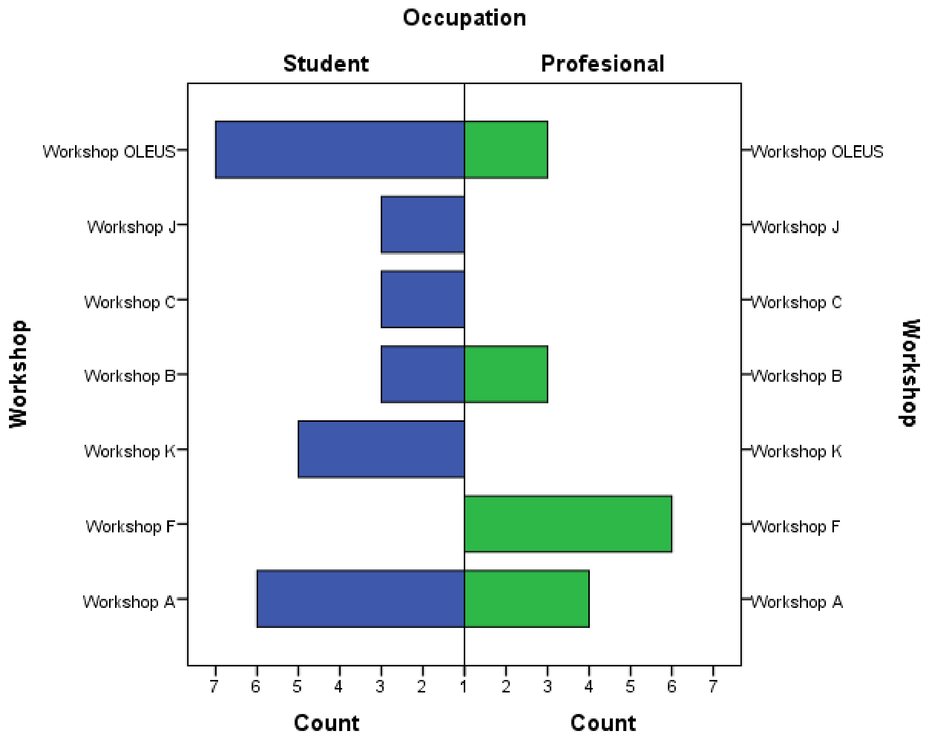


Figure 4-20-Student and professionals by workshop.

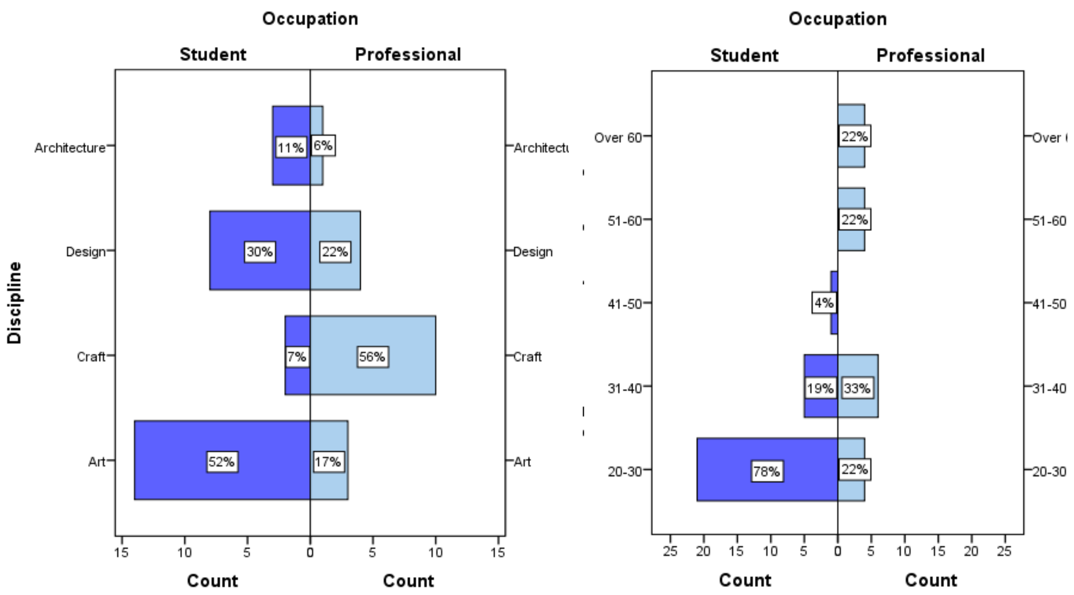


Figure 4-21-Distribution by age and occupation.

Perceptions of 3D printing

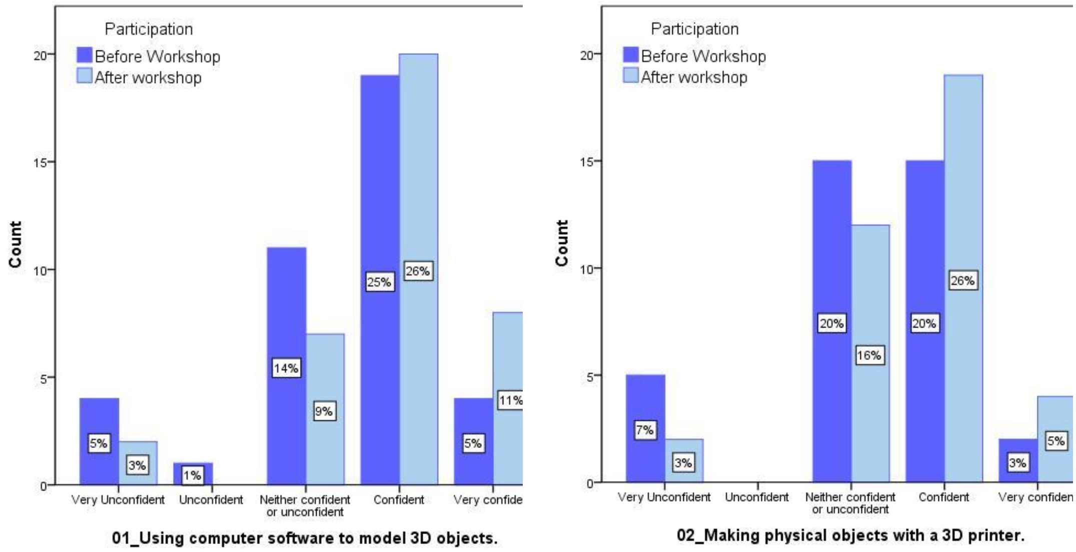


Figure 4-22a-22b-Confidence in 3D modelling and 3D printing before and after workshops.

Figures 4-22a and 4-22b show how the workshop contributed to developing the confidence of the participants in design using 3D software and making objects with a 3D printer. Self-reported confidence increased with the participation in the workshops, as one participant stated: “it was easier than I thought” Architect, Workshop A, diary entry.

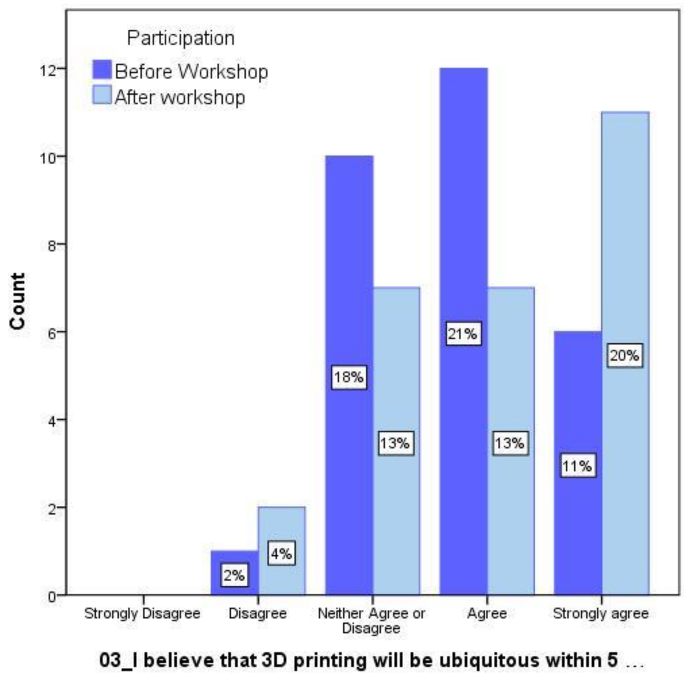


Figure 4-23-Impact of workshops in the perception of 3D printing dissemination.

Figure 4-23 presents how the 'perception of 3D printing becoming ubiquitous within 5 years' increased after participating in the workshops. This is caused by a better understanding of the technology and the possibilities that can offer within a creative practice, it is interesting to see how there is a sway in the willingness to participate in 3D printing experimentation (Figure 4-24). As we can see this relates to the perception of 3D printing being a potentially useful tool (see Table 4-8-Emergent themes from factor analysis.)

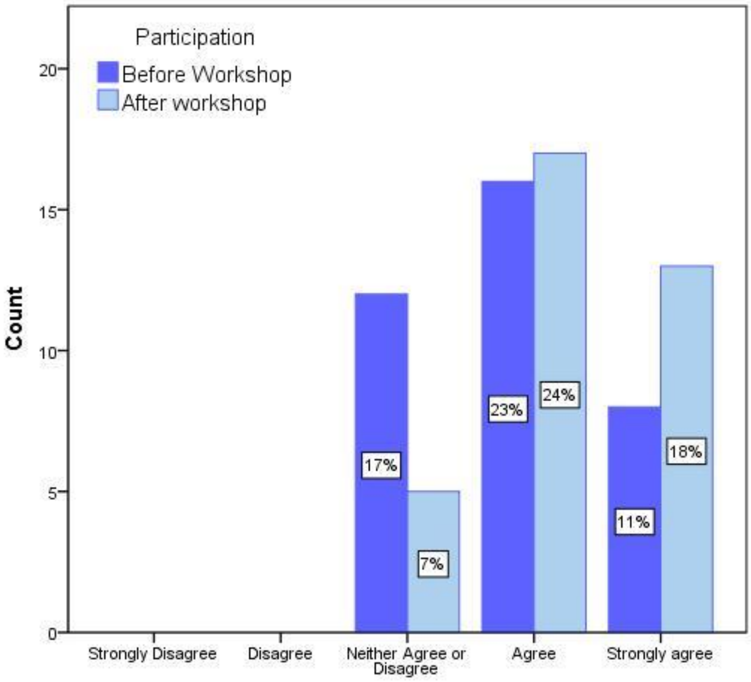


Figure 4-24-Impact on willingness to experiment with 3D printers.

It was within the scope of the workshops to reduce the impact of mass media in the perception of 3D printing. Hence, the activities were oriented to move away from the trends in the media and more towards a realistic representation of technological development. The fact that the perception that 3D printers were going to be ubiquitous[47] within five years increased offered a counter argument to what I believed, the myth created by mass media did not need to have a negative impact. Indeed, as we can see, there is a relation in the perception of ubiquity and the willingness to experiment with 3D printing after participating in the workshops.

[47] It is important to note that the meaning of ubiquitous was discussed during the workshops among participants.

At the same time there is a change in the perception of the integration of 3D printing within creative practices (Figure 4-25), this suggests a difference on how the technology is

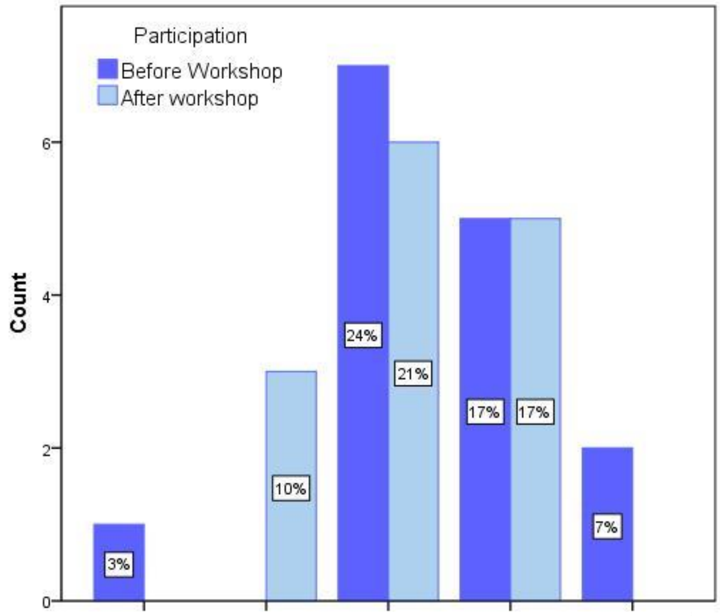


Figure 4-25-Impact on inclusion of 3D printing in creative practice.

perceived. This could mean that the technology is perceived as 'play' or fun experimentation, but perhaps not to be embraced within professional practice, and as such it may be deemed more applicable as per "fun for producing toys and small trinkets" (Stone Mason, OLEUS workshop,Diary entry).

According to Hirsch, the four stages of domestication of a technology are; appropiation, objectification, incorporation and conversion (Hirsch and Silverstone, 2003) Although the expression of interest by this participant denotes an inclination to adopt the technology it certainly marks a distance to practice. In many cases, participants voiced their interest on acquiring a 3D printer, which according to Silverstone is the first step in the domestication of a technology, however, workshops were too short in time to give participants enough time to evaluate the technology in depth. In some cases, participants voiced how they could see the 3D printers being ingrained in their studios, this could be identified- under Silverstone's theory- as the process by which a technology is expresssed within the household or domestic use and the way it is embeded within other practices, that is, second and third phase; objectification and incorporation (Ibid)

Age, perception of 3D printing and collaboration

In Figure 4-26, we can observe the relation between age and collaboration: the professionals and craft practitioners are more comfortable with collaboration than the younger practitioners or students. According to Sveiby and Simons, age and education level are directly related to the disposition towards collaboration (Sveiby and Simons, 2002). Moreover, by comparing the means of the responses of different age groups we can observe that the confidence levels of using design tools to create a 3D model and making physical models with a 3D printer decrease with age (Figure 4-27 and Figure 4-28).

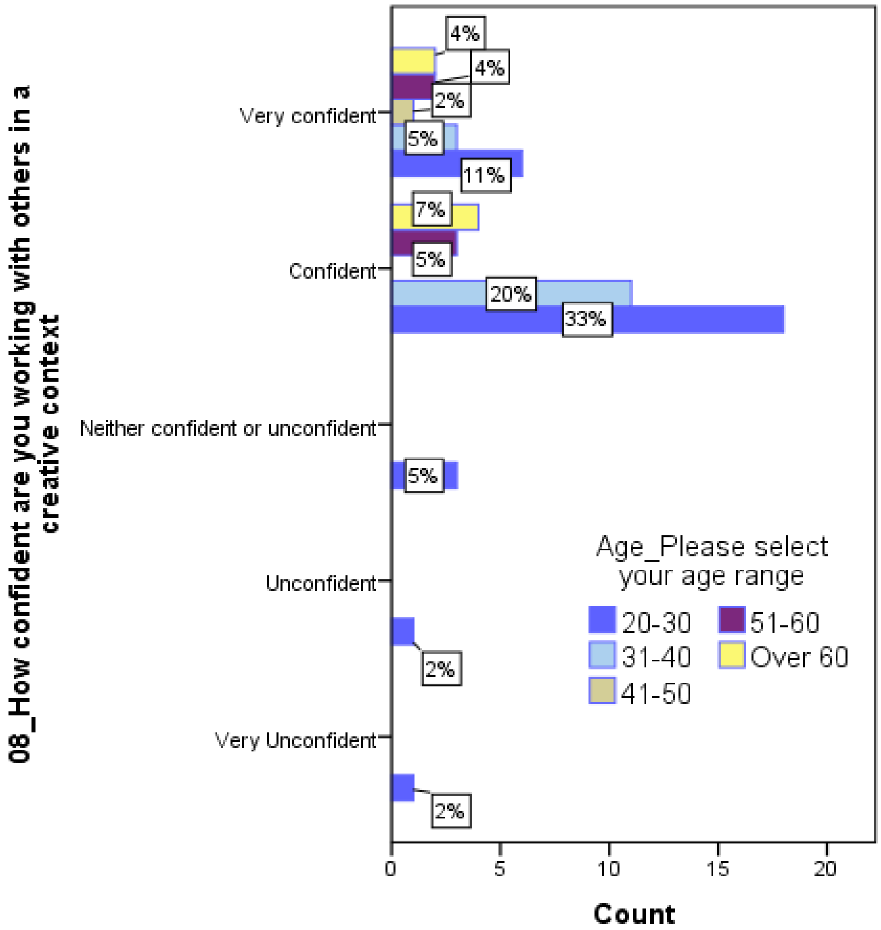


Figure 4-26-Collaboration confidence by age

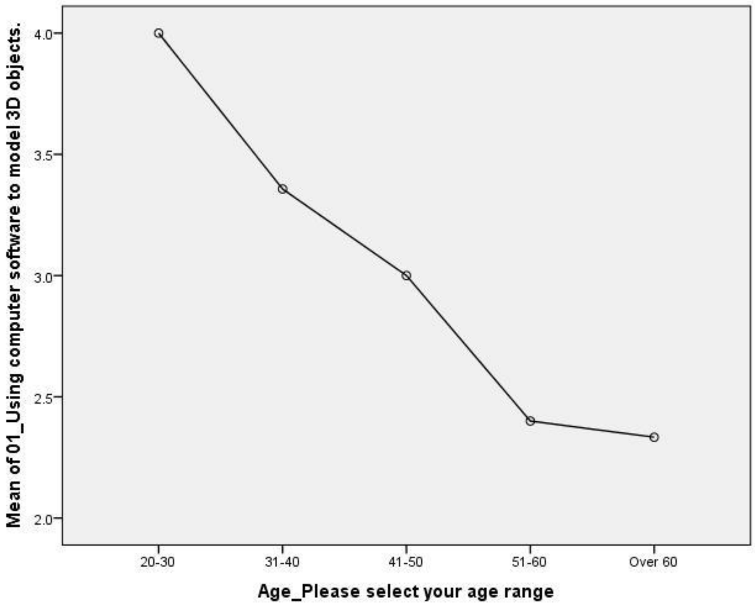


Figure 4-27-Age vs. Confidence in using computer software to model 3D objects.

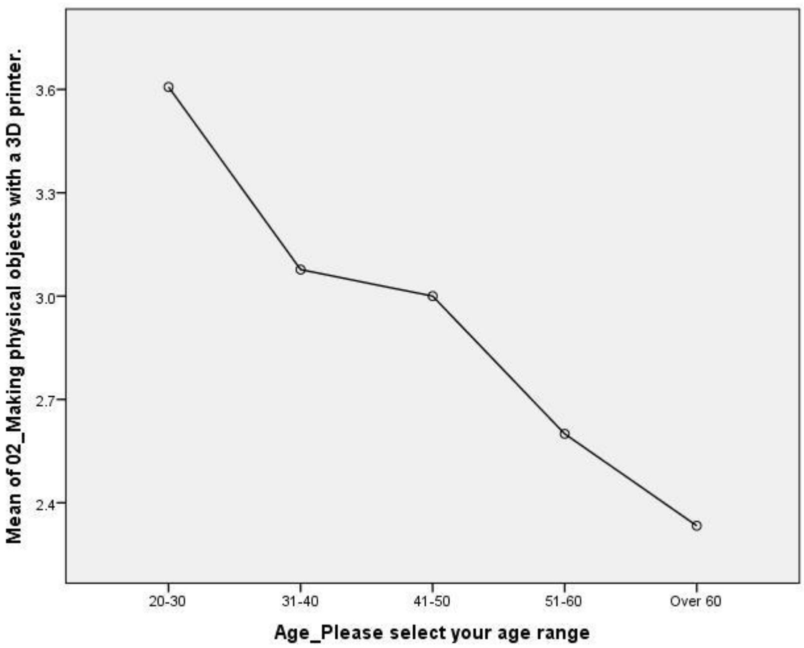


Figure 4-28-Age vs. Confidence in making physical objects with a 3D printer.

It is interesting to note that age is shown in the data to have a direct relation with the importance of working physically with the material, Figure 4-29, as well as, more optimistic perceptions of the future of 3D printing, Figure 4-30. However, this conflicts with the qualitative analysis of the discussions where older participants were more sceptical and critical of technological developments.

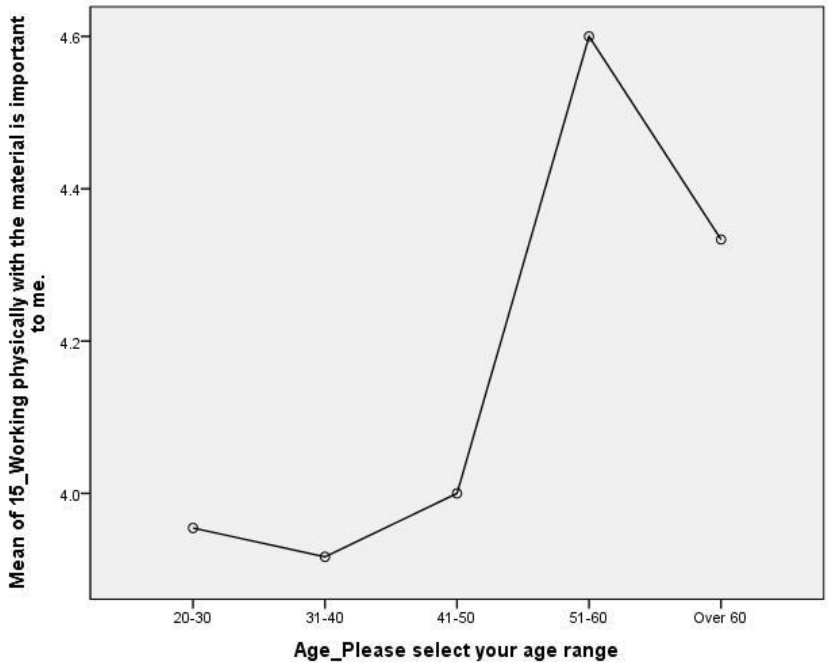


Figure 4-29-Age vs. Working physically with the material is important to me.

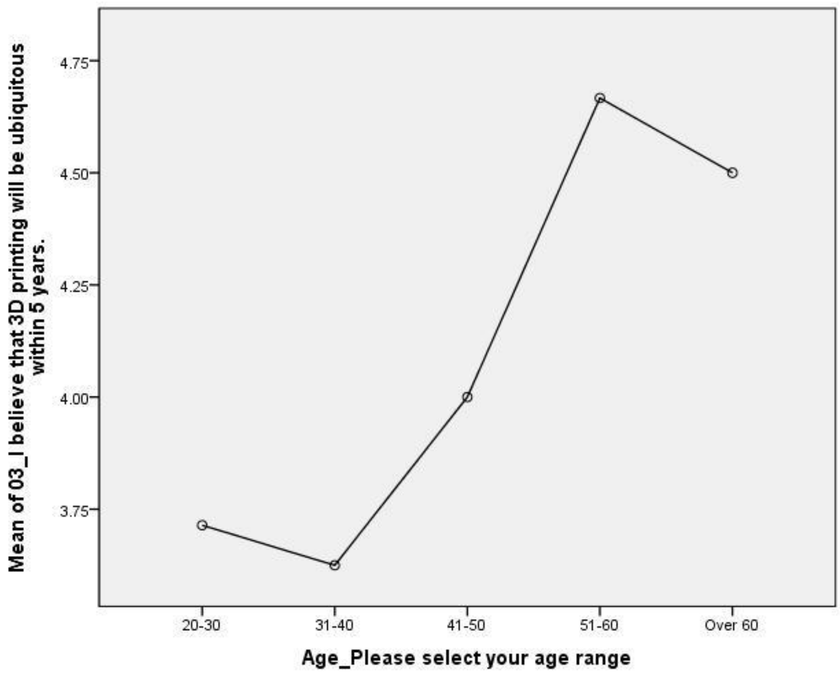


Figure 4-30-Age vs. I believe that 3D printing will be ubiquitous within five years.

This offers a profile of workshop participants; older practitioners were more prone to collaboration, less computer literate and had a deeper relation to material than younger practitioners. Moreover, the more seasoned practitioners expressed that their participation was prompted by fear more than creative curiosity, perhaps this is related to the relation between age and the optimistic expectation of the technology becoming ubiquitous within five years of the date of the workshops (2013) shown in Figure 30. As a participant later stated she was afraid that 3D printing could challenge her and her peers' creative practice (see Diary entry; workshop A, and transcript OLEUS)

Role of 3D printing within creative practices

After using the 3D printers participants felt more confident about the role of technology in the development of hand-based practices, as part of new creative practices (Candy and Edmonds, 2010a; Sporton, 2015). Figure 4-31 shows the impact of the workshops on the perception of technology as an influence in the emergence of new practices. After the workshop, participants were more readily viewing 3D printing as a process for creative production. However, Figure 4-32 shows a strong division about the perception of 3D printing as part of a handmade product. This question stirred some controversy and many of the participants did not respond in the survey after the workshop, however, in the graph we can appreciate that those who responded were showing defined positions. Although this subject was discussed in focus groups and interviews, it suggests that there is new technology that contributes to hand based processes but their products are not considered handmade. This supports the findings from the factor analysis (see Table 4-8) that identifies that there is an emerging creative practice related to 3D print but that cannot be considered a form of craft. However, in the case studies I challenge this notion, additionally the relation between craft and technology was debated frequently in the focus groups. I offer an in-depth analysis of this question in chapter 7.

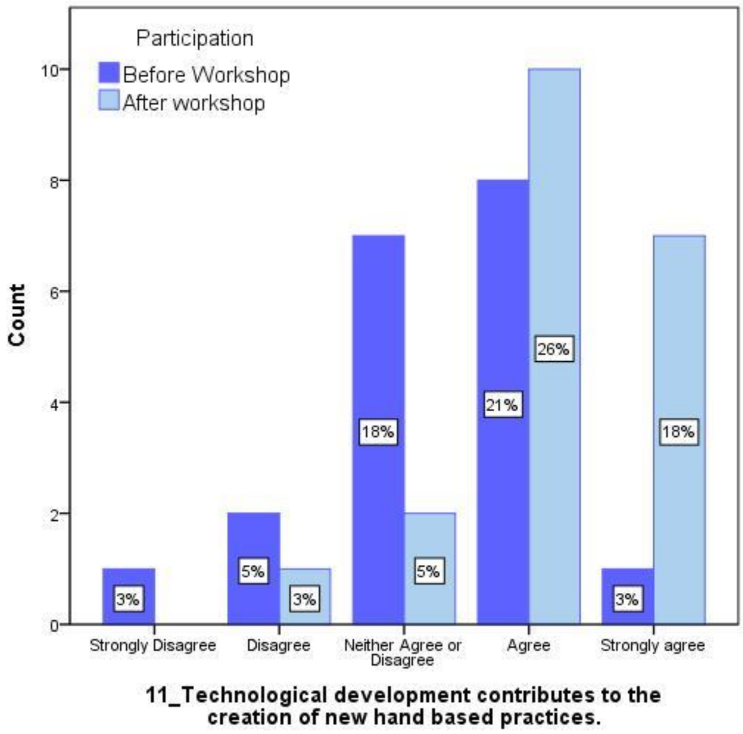


Figure 4-31-Technological development contributes to the creation of new hand based practices.

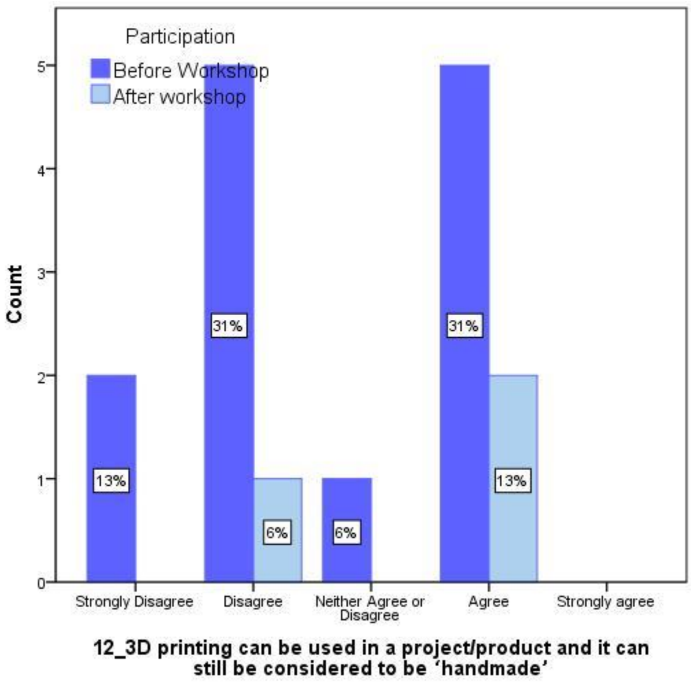


Figure 4-32-3D printing can be used on a project/product and it can still be considered to be 'handmade'.

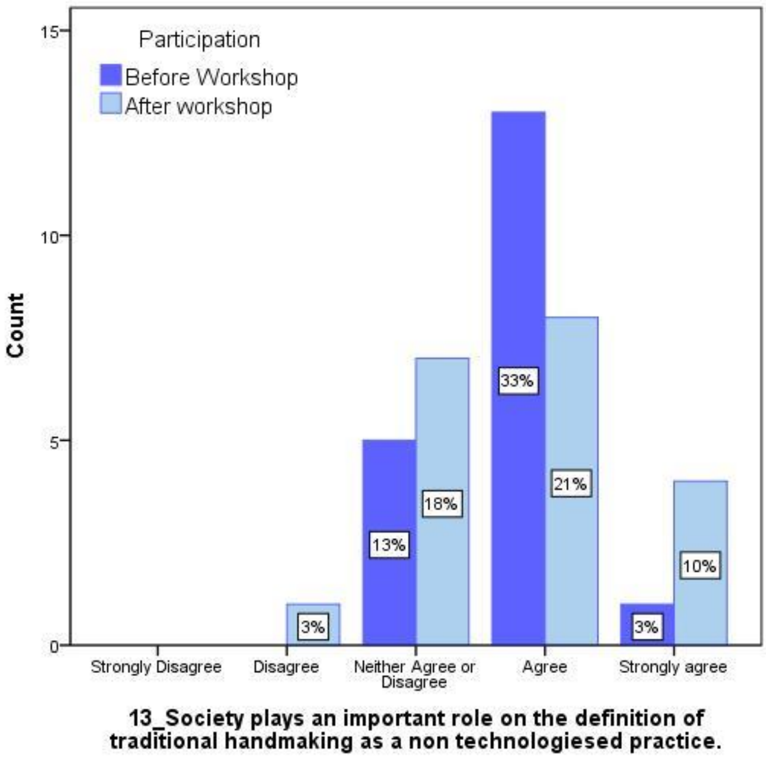


Figure 4-33-Role of society in the definition of the 'handmade'.

Perceptions about the role of society and the wider context for emerging technology shifted towards stronger opinions(Figure 4-33), including disagreement. Older creative practitioners believed that technology enabled professional intruders to thrive within a creative context without having the adequate knowledge (Diary entry, Pilot workshop; OLEUS). I introduce this notion later on this thesis as *professional meddling*, one of the causes for the confrontation of emerging technologies among creative practitioners. According to these participants the use of such technologies (i.e. 3D printing and laser cutting) by a community of amateurs and hobbyists offered unfair competition, this was linked to online platforms like Etsy and branded as “naff craft”, this was further debated in the focus groups. There is profuse literature about the role of amateurs within craft and creative practice, in this case I find particularly appealing the defence of amateurism as a way to push craft development by developing links with a community (Gauntlett, 2017) or even if it is just to distance craft from amateur production (Koplos and Metcalf, 2010).

Special cases/conflicts

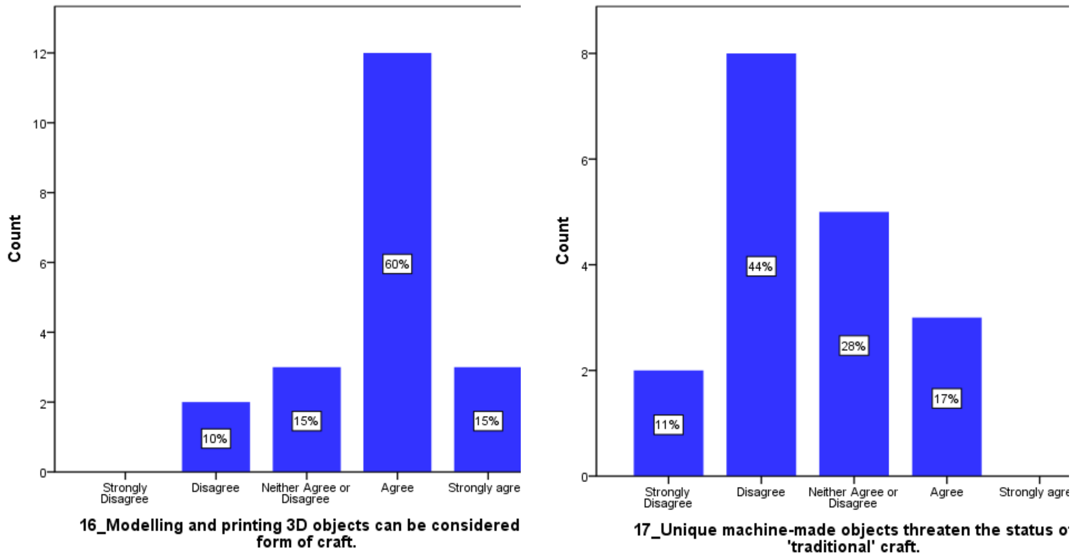


Figure 4-34-Modeling and printing 3D objects can be considered a form of craft and Unique machine-made objects threaten the status of 'traditional' craft.

Questions 16 and 17 (Figure 4-34) show overall agreement and disagreement respectively. These graphs show nested answers from before and after questionnaires. However, they are still interesting given the strong overall opinions shown. While participants generally accepted the notion of modelling and 3D printing as a form of craft, those who were willing to embrace it did not want to accept it as a part of their professional process. According to Philpott emerging digital fabrication offer access to processes that otherwise would be too expensive or complex for a small company or a practitioner (Philpott, 2012), after proposing participants to think about a way they could accelerate or generate tools some of them changed their attitude and even suggested some experiments that would lead to the early stages of WEARD3D.

The value of machine made objects

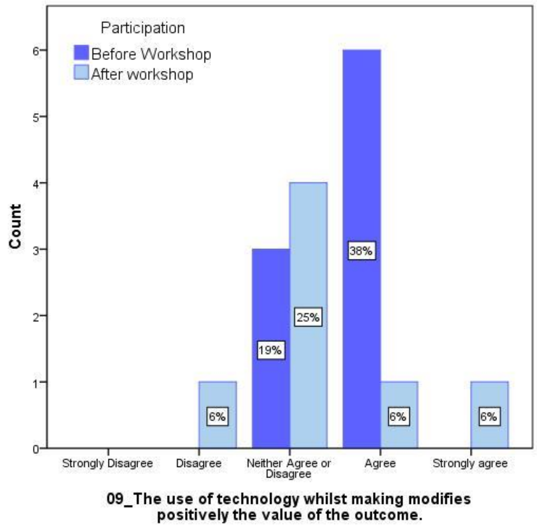


Figure 4-35-The use of technology whilst making modifies positively the value of the outcome.

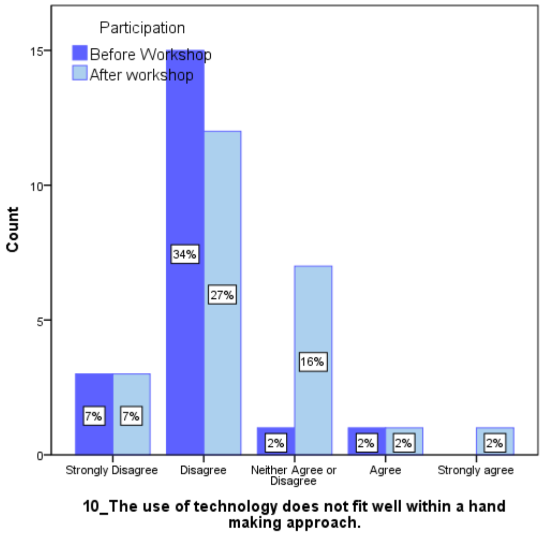


Figure 4-36-The use of technology does not fit well within a hand making approach.

The figures above, question nine and ten, show more dispersion in the opinions, however, it is important to note that fewer participants responded to the questions before and after the workshops. The graphs suggest that there could be an increased perception of the value of technology, or alternatively, a change in the definition of technology.

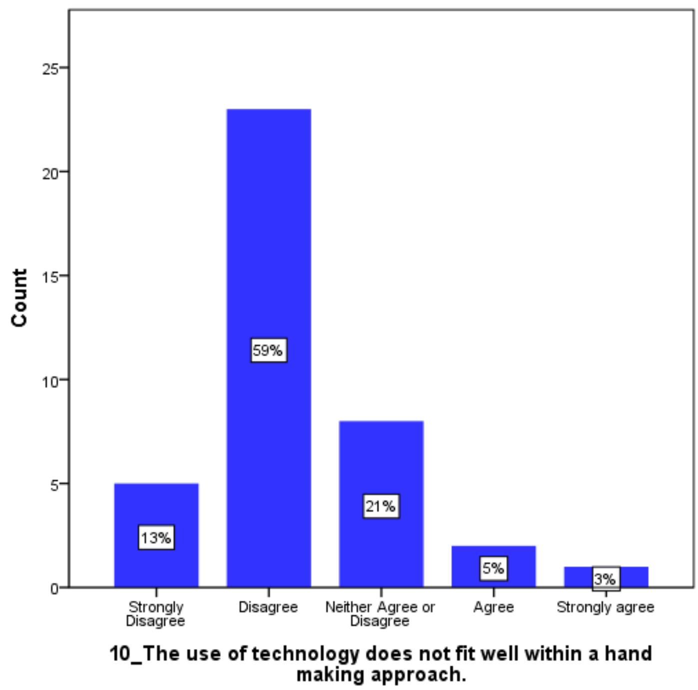


Figure 4-37-Question 10, The use of technology does not fit well within a hand making approach.

Considering the total of responses to question 10 clearly shows disagreement on the use on perceptions about the role of technology and the notion of the handmade, although there is overall disagreement with the statement that 'the use of technology does not fit well within a hand making approach'. Considering the results of questions 11 and 12 there seems to be a conflict in which the definition of the role of 3D printing within a creative process is contested.

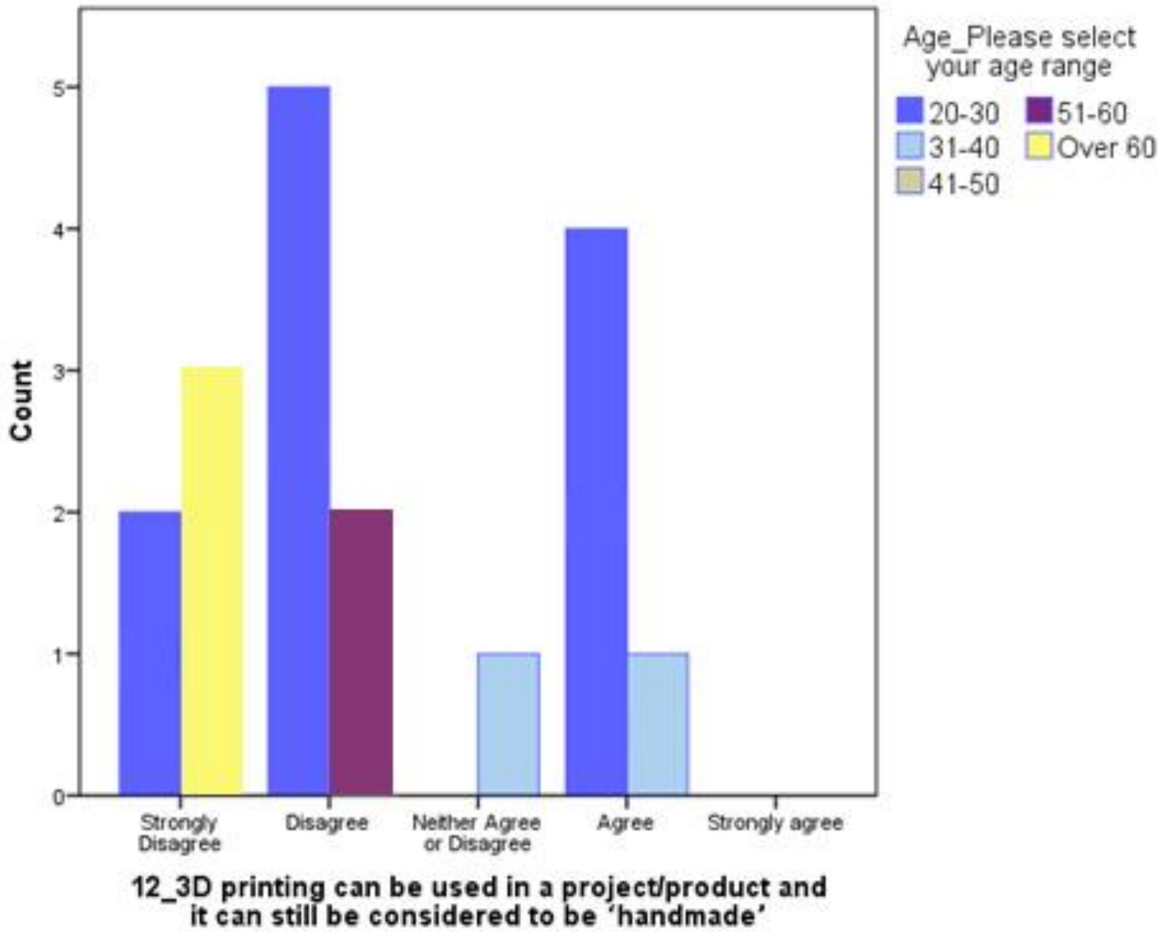


Figure 4-38-Generational difference in the perception of 3 D printing within handmade practices.

Using one-way ANOVA analysis (using a significance of 0.1), I identified three related variables with question number 12, that is Age (shown above). However, it is more interesting to see in the graph below how there is a direct relation between the answer to question 15 - *working physically with the material is important to me,* and question 12, this suggests that the stronger the relation between the practitioner and the material the more unlikely they are to appreciate a 3D print as a handmade object. In conflict with this view are the results from questions 10 and 16, where participants mostly agreed with the idea of considering modelling and 3D printing as a form of craft, and where the definition of the role within craft making is contested.

Factor analysis

A factor analysis is a way of finding relations between sets of questions, revealing 'hidden organizations' in the data (Yong and Pearce, 2013). This can be used to assess how well designed a survey is as well as simplifying the analysis. Factors act as clusters of questions with a high level of significance. These clusters can be used as units of meaning. If we look at the chart of correlation and the correlation matrix graph below - Figure 4-39 - we can see how some of the questions have a strong correlation, for example questions six, seven and eight[48]. We will use this to further the analysis of the results in the following section.

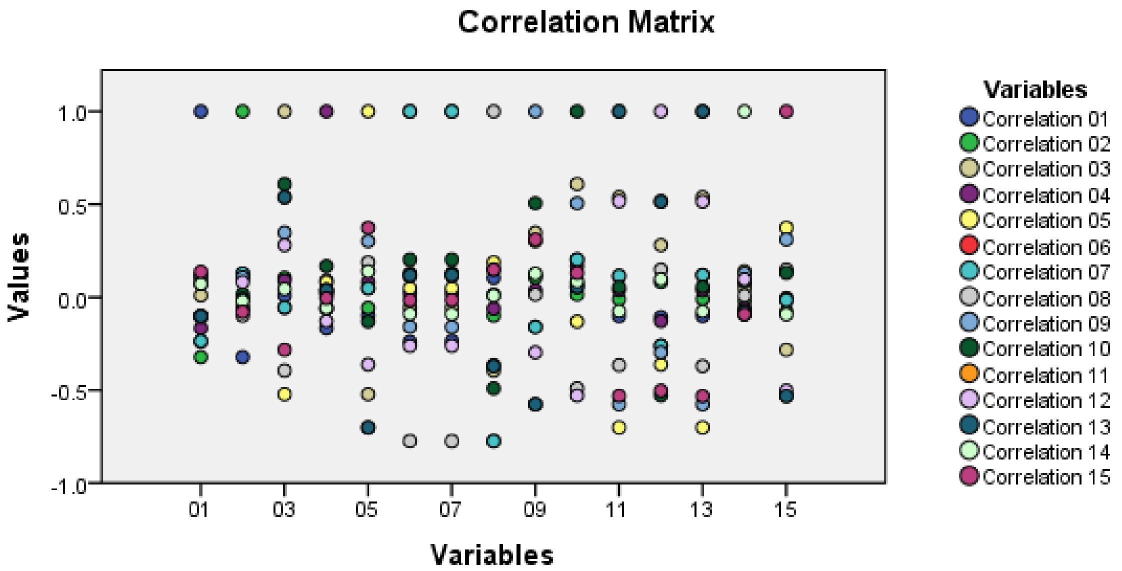


Figure 4-39-Correlation matrix graph.

Factorial analysis uses a correlation matrix to conglomerate sets of questions. The graph (Figure 4-40) and Table 4-6 portrays the overall representation of data within each factor. In this case, six factors represent most of the data, and especially the first four represent 70.4% of the data.

[48] A correlation factor defines how well related two items are, a strong correlation index would be anything between 0.75-1.00, thus representing that the two questions would have related responses. A negative correlation would represent a negative relation, that is, if "A" and "B" have a -0.80 correlation there is a strong relation between the answers, but it is negative; those who said yes to A would have said no to B, or vice versa.

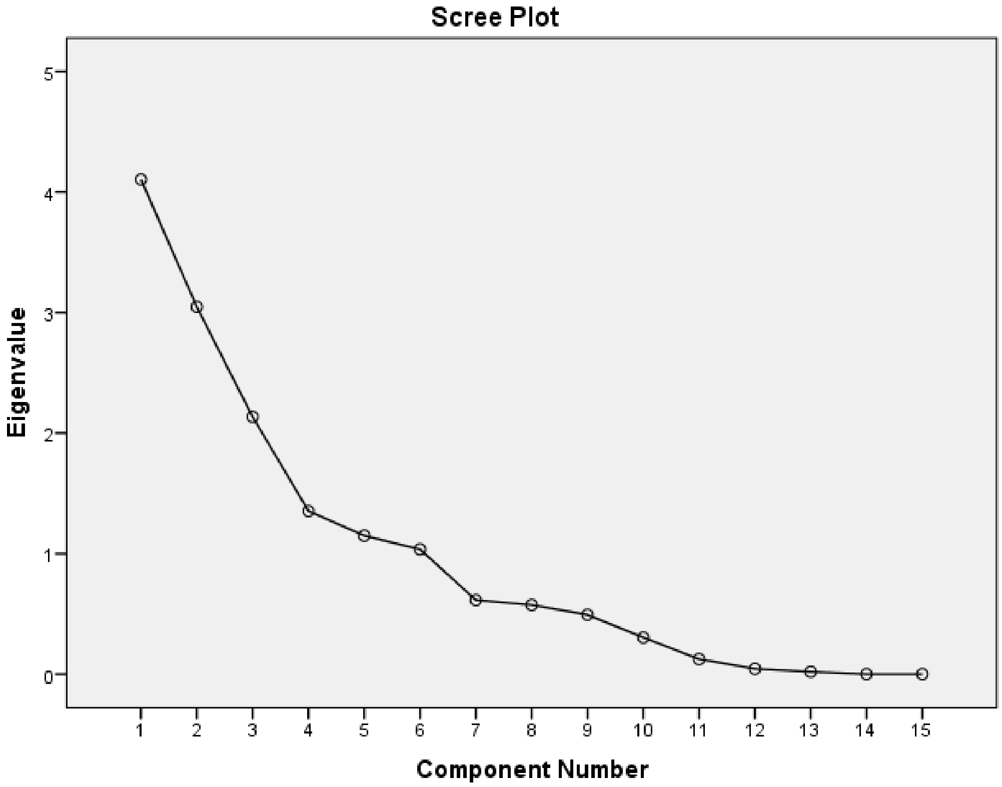


Figure 4-40-Factor analysis 1, loading analysis. After component five the change is minimal.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.105	27.364	27.364	4.105	27.36	27.364	3.990	26.603	26.603
2	3.048	20.319	47.683	3.048	20.31	47.683	2.936	19.571	46.174
3	2.135	14.237	61.919	2.135	14.23	61.919	2.250	15.002	61.176
4	1.353	9.022	70.941	1.353	9.02	70.941	1.385	9.232	70.408
5	1.149	7.663	78.604	1.149	7.66	78.604	1.140	7.600	78.008
6	1.036	6.904	85.508	1.036	6.90	85.508	1.125	7.500	85.508
7	0.614	4.094	89.602						
8	0.574	3.827	93.429						
9	0.493	3.285	96.714						
10	0.304	2.026	98.740						
11	0.125	0.832	99.572						
12	0.045	0.297	99.869						
13	0.019	0.130	99.999						

Table 4-6-Principal component analysis. Component number six has a cumulative 85.508% representation of the data.

For the first factor analysis, six components were selected representing 85% of the sample. Once the factors are selected the analyst must review the table of component loadings to give a meaning to these factors to relate them to other domains or questions. Table 4-7, below, shows how the factor loadings amalgamate questions to create a new organization of meaning (Yong and Pearce, 2013). Negative values represent a negative relation within the unit of meaning. In component 1, the first and second loadings (0.95, 095) indicate that measures 11 and 13 can be used to describe Factor 1. In this case, it corresponds to the following questions: technological development contributes to the creation of new hand-based practices; and, society plays an important role in the definition of traditional hand making as a non-technologised practice. It is important to note that variables 5 and 15 have a relatively high negative score - normally loadings major of 0.7 are used (Yong and Pearce, 2013), this means that the hidden Factor 1 is opposite of 5 and 15. Then, Factor 1 can be defined as the perception of 'new practices emerge with new technologies'.

Rotated component matrix

	Component/Factor					
	1	2	3	4	5	6
11	0.956	0.154				
13	0.956	0.159				
5	-0.781		-0.219		0.178	0.254
15	-0.666		0.119	-0.181		-0.309
12	0.666	-0.340	-0.281	0.250	-0.134	0.244
7		0.975		0.103		
6		0.975		0.105		
8	-0.257	-0.840	-0.347			
10		0.290	0.884	-0.127	0.136	
3	0.561		0.781			
9	-0.523	-0.191	0.724	0.146		0.145
2			0.134	0.838	-0.203	
1		-0.189	0.174	-0.710	-0.391	
4			0.113		0.926	
14						0.928

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

11_Technological development contributes to the creation of new hand-based practices.

13_Society plays an important role on the definition of traditional hand making as a non-technologised practice.

05_I will soon incorporate 3D printing into my creative work.

15_Working physically with the material is important to me.
12_3D printing can be used in a project/product and it can still be ‘handmade’.
07_I feel more confident about using 3D printing within my creative practice than before.
06_The workshop provided a new experience for me.
08_How confident are you working with others in a creative context.
10_The use of technology does not fit well within a hand making approach.
03_I believe that 3D printing will be ubiquitous within five years.
09_The use of technology whilst making modifies positively the value of the outcome.
02_Making physical objects with a 3D printer.
01_Using computer software to model 3D objects.
04_My creative practice lends itself well to experimenting with 3D printing.
14_It is easier to get emotionally attached to an object made by hand, than one made by a machine.

Table 4-7-Rotated component matrix and relation of questions. Highlighted main item loadings.

The rest of the factors are identified as follows:

- Factor 1: New practices emerge within technology but cannot always be considered hand-based practices.
- Factor 2: increased confidence in individual creative experimentation with 3D printers.
- Factor 3: 3D printing will be a positive addition to a creative process.
- Factor 4: Lack the opportunity to 3D print. Have the skills to model but remain uncertain about 3D printing.
- Factor 5: I am willing to experiment, lack knowledge about design and 3D printing.
- Factor 6: Handmade objects are emotionally more valuable than machine-made.

Each factor represents an unknown or ‘hidden’ dimension, which can be used as a statement per se, or to test a relation amongst other factors or questions. Factor 1 is used here to analyse participant’s perceptions on the relation of emerging technologies with the emergence of new practices or ways of making. By using other tests like mean comparison or ANOVA we can compare the responses of participants to other questions and validate hypotheses. In the following analysis, I present the results of analysing six sets of factors described in Table 4-8. Here, I present the results of the six sets and an overarching analysis at the end of the section.

Test	Factors	Names/Content	Meaning	Section/Appendix
FA 1	FA1.1	Q15B-A1	New practices emerge within technology but can not always be considered hand-based practices.	2.1
	FA1.2	Q15B-A2	Increased confidence in individual creative experimentation with 3D printers.	
	FA1.3	Q15B-A3	3D printing will be a positive addition to my creative process.	
	FA1.4	Q15B-A4	Lack the opportunity to 3D print. Have the skills to model but remain uncertain about 3D printing.	
	FA1.5	Q15B-A5	I am willing to experiment, lack knowledge about design and 3D printing.	
	FA1.6	Q15B-A6	Handmade objects are emotionally more valuable than machine-made.	
FA 2	FA2.1	Q15Before1	3D printing could be considered a form of craft.	2.2
	FA2.2	Q15Before2	3D printing will bring new exploratory practices.	
	FA2.3	Q15Before3	Can Model 3D, uncertain about 3D printing.	
	FA2.4	Q15Before4	3D printing is perceived as an ICT technology.	
FA 3	FA3.1	Q15After1	I am willing to experiment with 3D printing, but not as a hand-based practice.	2.3
	FA3.2	Q15After2	3D printing will be accepted as another creative tool.	
	FA3.3	Q15After3	I am confident in 3D printing and design.	
	FA3.4	Q15After4	The workshop increased my confidence with 3D printing.	
	FA3.5	Q15After5	3D printing does not conflict with the handmade.	
FA 4	FA4.1	Q17BA1	3D printing is useful but can not be considered a form of hand-based manufacture.	2.4
	FA4.2	Q17BA2	3D printing is not a threat to traditional ways of making.	
	FA4.3	Q17BA3	Embracing digital technology in my own practice, but not collaboratively.	
	FA4.4	Q17BA4	Can 3D print but not 3D design, printing is part of a creative process.	

	FA4.5	Q17BA5	Willing to embrace 3D printing but not as a way of producing final pieces	
FA 5	FA5.1	Q17After1	3D printing will be ubiquitous, but it won't be as a form of craft	2.5
	FA5.2	Q17After2	I have soon embraced 3D printing as a positive addition to my process	
	FA5.3	Q17After3	I am very confident when 3D printing and 3D modelling	
	FA5.4	Q17After4	3D printing could be just another creative tool	
	FA5.5	Q17After5	The workshop increased my confidence in embracing 3D printing as a tool	
FA 6	FA6.1	Q17Before2	Using 3D printing won't be considered a form of craft	2.6
	FA6.2	Q17Before3	Can make 3D prints but cannot do 3D models	

Table 4-8-Emergent themes from factor analysis.

4.5. DISCUSSIONS AND QUALITATIVE DATA

In this section, I introduce additional qualitative data from the activities and focus groups of the workshops. In each workshop, there was a creative group activity that consisted of modelling an object using Autodesk Tinkercad for two minutes and then passing it on to the next person; every participant would get a chance to contribute to each of the designs generated. This co-located group activity produced many files to analyse; these models portray details about how the overall group understood different aspects of 3D design and are used to analyse the success of the workshops as a learning activity. Additionally, these digital collaborations triggered discussions about 3D modelling and printing and offered a contrast with similarly timed hands-on collaborations. Participants expressed strong opinions about the difference between the two activities. Moreover, the behaviours changed radically: the digital models seemed to have less value and were often changed, or even deleted, where the hands-on creations of others were always disrupted by additive processes rather than subtractive as would happen during the digitally mediated collaborations.

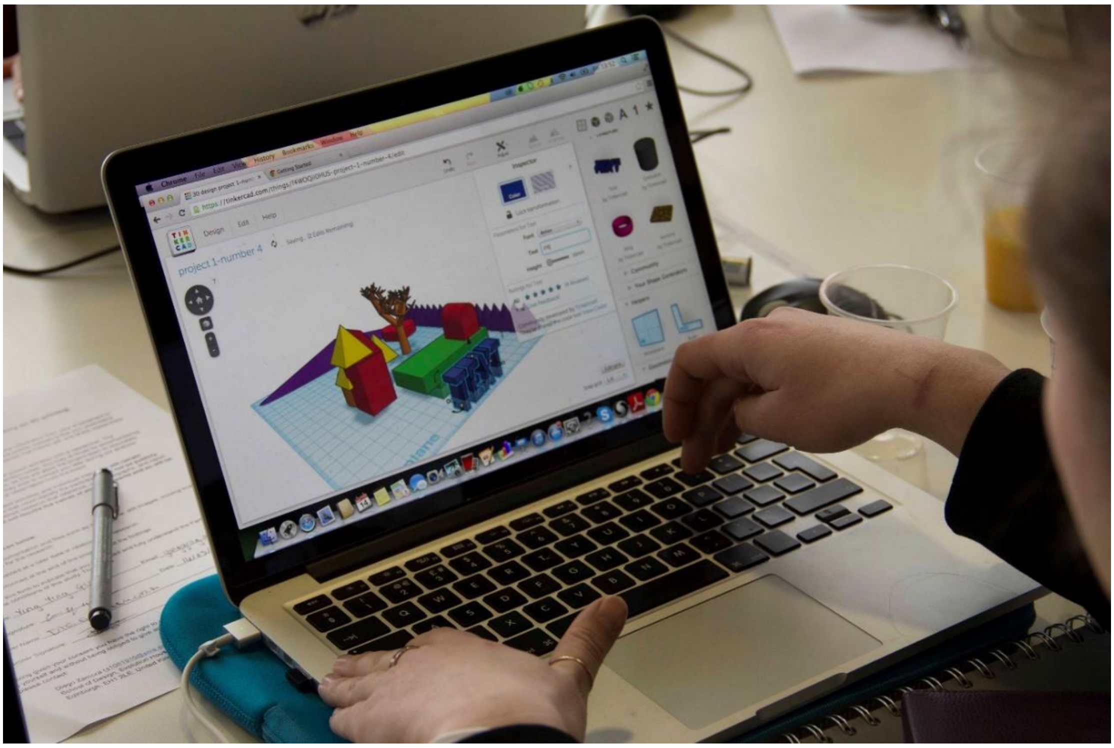


Figure 4-41-Collaborative digital design.

More than sixty 3D models were created this way, however, to foster analysis and encourage more in-depth learning about the process of 3D printing I organised a democratic vote after the activity to select the favourite of the session. This activity aimed to offer an opportunity for reflection on the process and at the same time sharing the intention of design and surprises that the joint manipulation of the pieces could have brought. During this exercise, we paid attention to the complexity and integrity of the models to analyse printability; this was done by using a projector and collectively looking at the 3D files, generally before the lunch break.

Discussing the quality of the 3D models was a checkpoint to capture their progress, in most of the workshops it was a somewhat entertaining activity since the creations have a flair for chaos to them. Although, some of the participants expressed their disappointment about how poorly their original idea had been distorted “started the happy Easter egg and then someone added swearing.” (workshop C-Tinkercad discussion) moreover, some others expressed how stressful it was trying to manipulate objects in space with a time constraint.

Figure 4-42-Time attack tools for digital co-located collaboration.

The use of this time attack game sparked debates about ownership, design intention and originality. These concepts and ideas expressed, were either brought up in the focus groups or captured as annotations and reflective notes in the research diary at the end of the workshops.

Figure 4-43-Set up and conversation props.

4.6. ROUND 1 (PILOT + WORKSHOPS A, B, C)

As mentioned before the first full workshop (OLEUS) was organised over two days with two more researchers. Running a workshop as a team of facilitators simplified the process of gathering data. Hence, the data and the quality of the objects produced by participants was very high. The use of brainstorming and reflection provided participants with a critical framework to develop concepts and approach 3D printing. This first group had a longer time for the development of models. Additionally, the fact that the final piece was a group creation made all objects to be owned collectively, resulting in different levels of attachment depending on the time dedicated to specific parts of the process. Those who worked the digital model extensively and struggled with it developed a strong attachment to the piece, similarly to those who participated in the cleaning and postprocessing of the 3D prints; this was in most of the cases quite demanding and risky as some parts of the 3D prints were too brittle, Figure 4-44.

Figure 4-44-Participant postprocessing or “cleaning" a 3D print by removing the support material.

These differing views of how they grew attached to the objects was brought up during the discussion; “because it came out broken I got attached” This suggests that the exertion of physical effort was what made most of them establish a bond with their creations. Arguably, there was a bond before that, as modelling was difficult for some of them “you have put effort on that and is now yours” (Discussion, OLEUS workshop). As we have seen, getting hands-on action by either 3D modelling or cleaning the models contributed to the bonding with the object. Although most participants were unimpressed about the size of the 3D prints they all experienced certain attachment with the creations, this could be influenced by the hands-on material prototyping before 3D modelling. Additionally, in this workshop, there was a brainstorming session, which boosted the originality of designs.

Figure 4-45-Prototyping stage, pilot workshop.

This deeper level of thinking before and during making provided a better ground for discussion. However, the debate was dominated by those with strong opinions. Ideas about ownership, distribution, displacement of labour, risk and errorful explorations were brought up.

During this workshop, it came up for the first time how older participants were more confident about creative collaborations as well as exhibiting their work in public. This difference frequently happened through the whole set of workshops. According to Sveiby and Simons claim, seasoned participants tend to develop more collaborative relations (Sveiby and Simons, 2002). Furthermore, a collaborative dynamic emerged through the workshops where younger participants assisted those who were struggling to operate their computers to create a three-dimensional geometry, usually those with lower IT skills. In the other hand, the practical expertise of craft and making skills of those with more experience was left patent when drawing and making were central in the activities.

> *"My hands govern themselves, but on the computer, I have to think about it. My hands will just do it, and I can just think about something else, which*

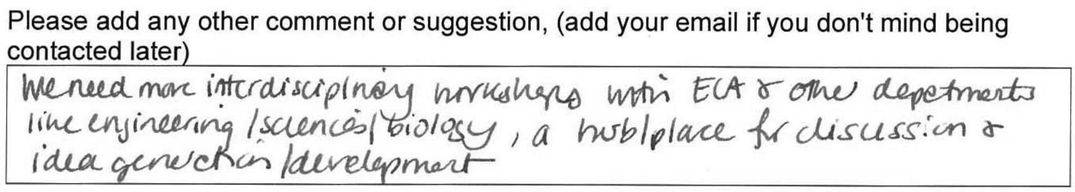
is very nice, I can ponder what I'm having for tea. But if I'm on the computer I am going to have to concentrate" Workshop C.

This helped fuel the perception of a generational difference when dealing with digital tools;

> *"But could that be…kids who are now young, for them digital tools are like clay for us" Workshop D.*

Despite voicing the perceived difference between their professional careers and skills set, feedback shows that the activities were highly appreciated, and students welcomed the mix of professionals with students of different generations (appendix B feedback)

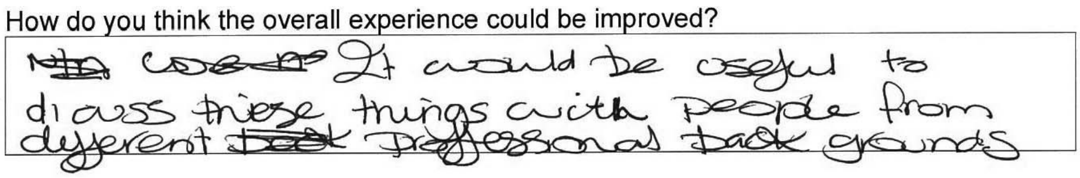
However, the first workshop I ran on my own was not as successful as the pilot study had been; there were far too many participants and hardly any time to look at the 3D prints before the discussion. Differently, to the following workshops, 3D printing happened simultaneously to the focus group; this limited the discussion and the impact that the 3D printed objects had on them.



Please add any other comment or suggestion, (add your email if you don't mind being contacted later)

We need more interdisciplinary workshops with ECA & other departments like engineering /sciences/ biology, a hub/place for discussion & idea generation/development

Figure 4-46-Written feedback; we need more interdisciplinary workshops.



How do you think the overall experience could be improved?

It would be useful to discuss these things with people from different professional back grounds

Figure 4-47-Writen feedback; it could be useful to discuss this things with people from different professional backgrounds.

To replicate the results of the pilot workshop I decided to organise a second two day workshop. This is presented in the data as workshop C, this was organised over two days but with a week between them as the intention of this workshop was to capture the perceptions around the capacity and workflows around 3D scanning as a supportive technology of 3D printing. The structure of this workshop is presented below;

Day 1; Friday 11th April 2014

-Introduction to 3D printing, and 3D modelling using TinkerCad and Sculptris

-Modelling with clay,

Day 2; Friday 18th April 2014

-Analysis of 3D printed replicas of clay models

-Collaborative modelling using clay and using digital tools

-Working on personal projects

-Reflection

This workshop relied heavily in the use and manipulation of material as a way of prompting discussion and reflection. Having the two days separated by a week allowed me to scan and 3D print all the clay models that were produced on the first day. This dichotomy of analogue vs digital collaborations was a source of controversy and fostered the confrontation of the divide between those who were more versed in manual skills and those who related more to digital processes.

> *"It's easier to make an object out of something that's already an object, than it is to make an object on a computer screen which is essentially to the eyes something which is flat. You have to imagine it as a volume when it's not. Whereas this is already a volume [clay], so you're working in a different way". Craft practitioner, 30-40, Workshop C.*

To which another participant responded;

> *"I'm also thinking about the fact that you quite enjoy the way things rip and the way the material smudges and you didn't know it could do that. That materiality, you don't get a chance to play about with it, you have to imagine what that would be like but fundamentally there is that thing that people will always like: fiddling about with stuff…mess. It's like primary school again. Yeah, so it's maybe two separate things; like when photography came and it didn't stop people wanting to paint and I think it will maybe make what people produce with their hands different. But certainly, flat things and perfect spheres are easier than they used to be, but that sort of form would be really difficult to model on the computer than it would in clay." Ceramist, 50-60, Workshop C.*

This implies that the feeling of technology mediated creativity is limited in different ways. According to Hawking's, the act of "messing around" is what provides the ideal setting for learning new technical processes. As it would be discussed later in other workshops, this seemed to be deeply related to the need to manipulate materials directly, beyond the expressed concern of how 3D printing -or digital fabrication- can limit self-expression and experimental freedom (Treadaway, 2006). According Shillito et al. this feeling of detachment is influenced by the lack of haptic feedback (Shillito, 2013; Shillito et al., 2001), or as Adamson suggest the lack of a sensual relation with the material (Adamson, 2007a). The use of pressure sensitive tablets whilst designing seemed to smoothen these barriers.

Additionally, we discussed the role of the tool and observed how younger participants aided older ones with digital processes and tool sets. As a counter point, younger participants struggled with clay modelling. "I can not do much... I have too much imagination, but not enough skills" digital media student, 20-30.

One of the activities of this workshop was the handling and discussion of objects that had been designed using clay and then 3D scanned and 3D printed. This idea came from the suggestion of a participant from the pilot study who wondered if such a a process would have a "handmade quality". The images below portray the objects that were produced.

Figure 4-48-Digitalised zoo, collection of handmade clay objects and digital copies.

The collection of objects and replicas was taken as an experiment on replication and sparked some questions about ownership and the nature of digital creativity and the online exchange of files. However, the most interesting conversation was the one that sparked further discussion, that is, the *trace of the hand and* "human expression" which resonated with Jorgensen research and the notion that participants were removed from the process of 3D scanning and 3D printing (Jorgensen, 2017b). Among participants, experienced clay modelers produced smooth surfaces and round features that left little or no mark of the hand or tools, where other participants left traces of their actions all around. In the figure below it can be appreciated how the nails of one of the participants was imprinted in the clay model and then transferred to the digital model. This caused heated debate about the ability to express oneself[49] and caused controversy about the possible appropriation by others of a *personal mark.*

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[49] More examples of this can be found in the portfolio presented as part of this thesis in the Workshops section.

Figure 4-49-Personal mark, clay vase and digital counterpart.

This process of digital appropriation was brought to the fore when participants were put to do a timed digital collaboration using Tinkercad. The exercise consisted of the creation and sharing of a digital model that then was passed on to the following participant. Until everyone in the group had modified the model once for two minutes. This was a very dynamic way of prompting collaboration and was executed with clay models and digital 3D models. Interestingly, the digital models seemed to be changed and challenged more than their clay counterparts. When designing and passing on a design made with clay participants slightly modified what their colleagues made, differently, when designing in the virtual environment, objects and geometries were deleted or distorted frequently:

> *I started the happy Easter and then someone added swearing. Ceramist, 50-60, Workshop C, discussing collaborative activity with Tinkercad.*

Although, digital and clay models were modified - often in a humorous way- clay models tended to be more respected and slightly modified.

> *[speaking about clay collaboration] The next person would be more considerate of the other persons work. In CAD, I wasn't that bothered about other people's stuff, but in clay I felt like there was more effort put in. I wouldn't mess up something. Designer, 20-30, workshop D.*

An analysis of the transcripts of both activities (see transcripts of workshop C, at Appendix B) shows how participants were far more protective of the objects created by others when using clay. Additionally, the conversation suggests that the digital edition of others creations felt more casual and the outcomes were more surprising for participants; “the result is interesting, but I did not expect some of the features” Designer, 20-30, workshop C; discussing collaborative activity with Tinkercad.

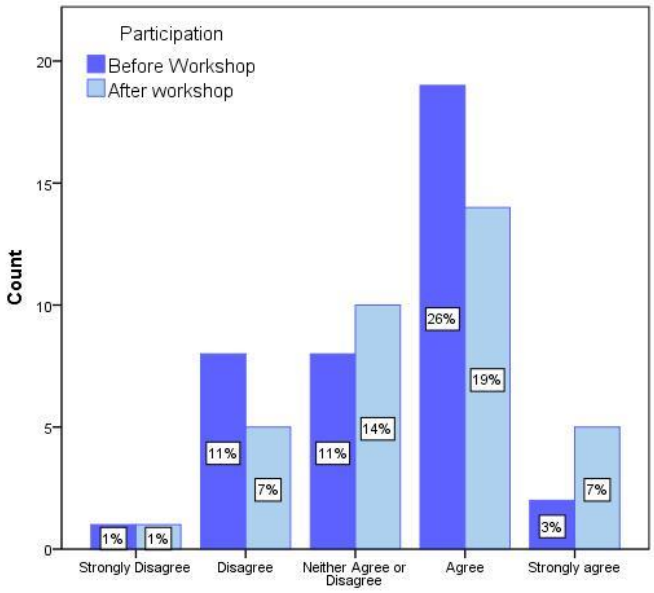


Figure 4-50-It is easier to get emotionally attached to an object made by hand, than one made by a machine.

All the workshops shared a digitally collocated collaboration and most of them had a drawing or making exercise with clay as the ones from this workshop. This prompted similar discussions and were used to further explore the role of collaboration within a 3D modelling and printing exercise.

Since the activities focused on the handling of clay and 3d scans the objects produced in workshop C are different to the rest of the outcomes of this round of workshops. Objects designed and printed in the first round were mainly produced by joining premade primitives and geometry generators, participants focused on this rather than creating their own objects from scratch. Although this allowed the building of complex models these lacked the purpose and creativity displayed in later workshops.

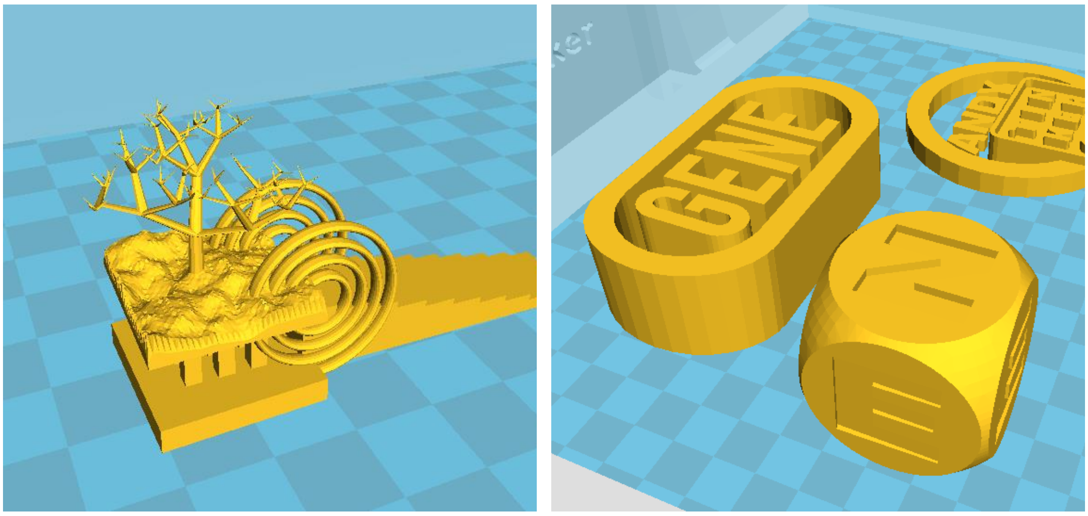


Figure 4-51-Round one sample of 3D models.

4.7. ROUND 2 (D,E,F)

This set of workshops was dominated by staff members from Edinburgh College of Art, although students participated in the events, discussions were dominated by staff and professionals. As such, the debates were better related to existing literature on the field. Additionally, the models produced during round two increased in complexity and level of detail in Tinkercad. However, it should be mentioned that the use of Sculptris contributed to the creation of complex organic geometries but not necessarily implied better understanding of 3D modeling or 3D printing.

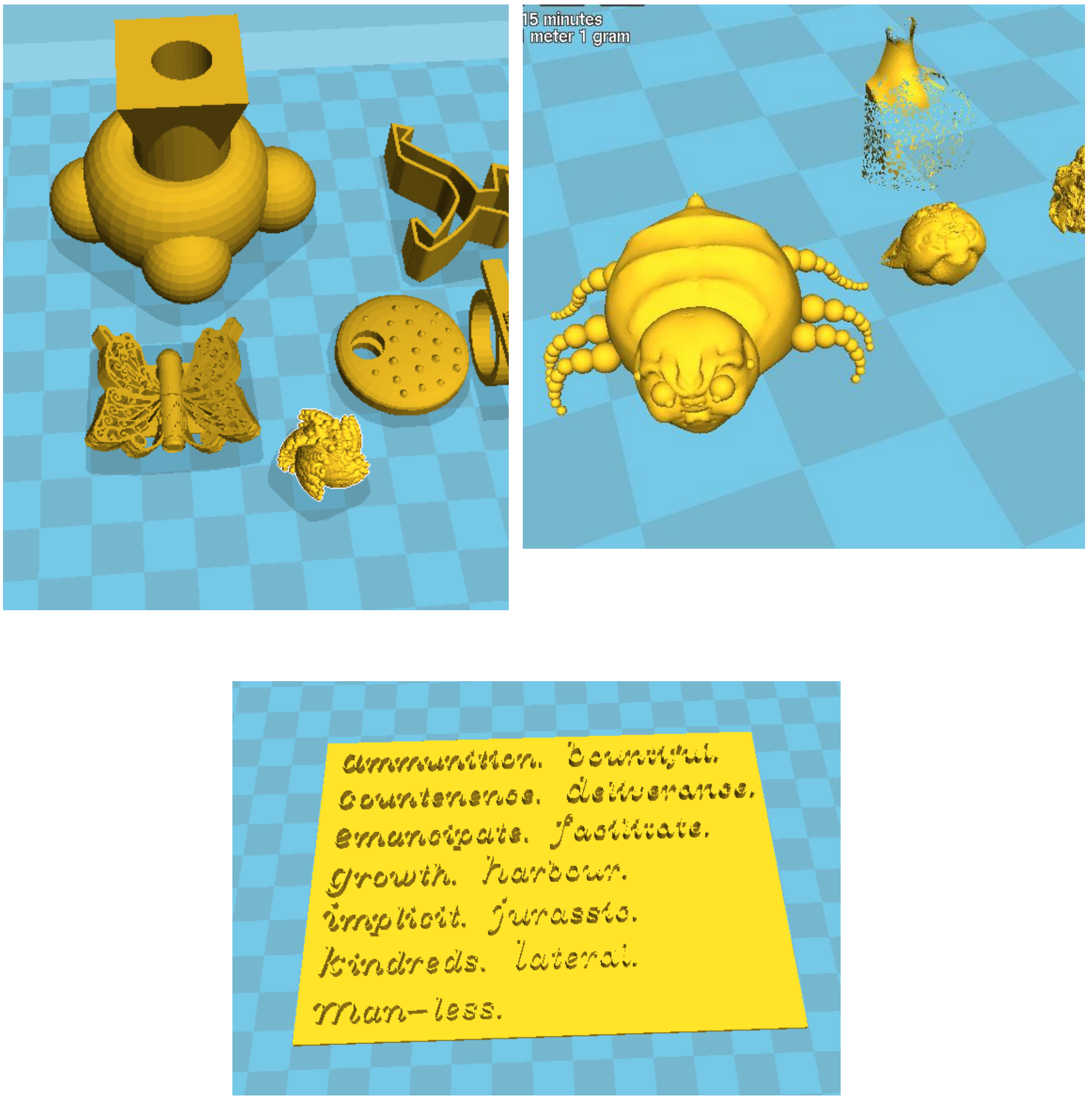


Figure 4-52-3D models from round 2 of workshops.

The strong presence of faculty members drove the discussions towards the role of technology within educational practice.

> *Personally, I have to take stock, it's not what I expected. I thought you'd just put something in at one end and it would come out of other. And the machinery itself, I find fascinating, it's this combination of extremely high technology and mechano. In terms of what I do, the main benefit for me is keeping up with this on behalf of students and their interests. People see 3D printing as such an abstract thing. And now it has become more tangible for me. I think at some point something might come into my head that would suit this. Right now it's too fresh. Photography lecturer, 50-60.*

Which expressed an intrinsic need of exploring the identities of those who engage with the technology as well as defining the roles within the wider creative community, something necessary and established in technology dissemination theories. According to Rogers theory early adopters are those who seek new frontiers within the domains of what is at hand, and then offer a role model for later adoption (Rogers, 2010)

> *The question is whether you are interested in how the technology, how artists, crafts people and designers think about it. And I think there will be slightly different emphasis. Because with art I think for me is about making things visible that aren't: either we don't see them in this form yet or it visualises things that haven't even been thought of. Craft practitioner, 40-50, Workshop D.*

From the perspective of a craft practitioner it seemed relevant to question the motivation and the roles of those behind technological innovation. However, in this a clear distinction was being made about the potential of use within different disciplines. This highlighted the need for a supportive experimental environment within Higher Education Institutions, beyond the university workshops, which resulted too clinical and "locked down". Some participants had previously tried to experiment with 3D printers and found too many barriers to develop their interest. This was well supported by students and staff in written and oral feedback, saying how needed it was to have a more open approach towards technologies that normally live locked in in a workshop and fenced off by a technician;

> *Well the 3D printers I've encountered before are the ones that are sealed units. Someone that knows what they're doing types in what needs to be done and mysteriously you come 3 hours later and it is removed. But there is no sense of someone wading in there and changing the colours as they come through. Art lecturer, 40-50, Workshop D.*

This echoes Sennett's perceptions of technology as a Pandora's box, where there is some disconnection with the work that hampers an emotional relationship with it, not allowing to pride on one`s work (Sennett, 2009, p. 295). Moreover, Latour offers an alternative view on Pandora's box as a black box that is to be opened to demystify science and technology (Latour, 2003). Despite this inclination towards closer exploration of the technologies that were being fenced off, the seasoned practitioners and educators added perspective to the discussions including perceptions of technological flows over time and the influence that such flows have had in photography and other creative arts. They remained far more sceptical about the dynamics of dissemination of 3D printing and framed it within existing practices.

> *[…] I think there's also a common sense that technology is progressive: it stands for progress and yet there is a hyperbolic view of technology. I think culturally a lot. But by the same token, I think people have talked about technology in terms of remediation: that they remediate what is already there. We tend to think of technology, the way it's presented in mass media, is totally new. Craft practitioner, 40-50, workshop D.*

Through the lenses of this participants the discussion about the use of technology within creative practice had a few beneficial implications as well as some critical pitfalls. However, as in previous discussions there was the perception of digital tools being somewhat limiting and often to be the culprits of driving the results. Hence 3D printing was evaluated within a toolset rather than a way of producing an *end product*, according with the participants this added value to the experimentation with 3D printing.

> *I've colour printed by hand and what an enormously costly and time-consuming business that was. And with none of the positive outcomes that I think digital technology offers to the final result, to be honest. […] But in terms of it's purpose; the idea of it being able to produce results that are part of a service, it's faultless. It's hard to learn and time consuming but it depends what your objectives are. [3D printing] It's a tool. Art lecturer, 50-60, workshop D.*

The perceptions of some of these participants seemed to confirm the notion that technological flows are based on additive and evolutive processes that build off from prevailing tool sets and workflows. This debate seemed to be centred around the appropriation of digital workflows of previous tools, therefore creating a displacement of knowledge and labour. Gregory Sporton defends that technology appropriates tools and workflows to simplify the cognitive transfer from traditional workmanship into digital tools where the new processes are defended to be "their replacements, usually assumed to deliver a similar experience with an ever-greater efficiency, are the evolutionary successors of the original idea." (Sporton, 2015, pag. 2). However, McCullough's main thesis in his seminal work; *Abstracting Craft: The Practiced Digital Hand,* is that digital technologies are not to be used "so much for automating tasks as for abstracting craft" (McCullough, 1998, p. 8)

Participants made evident their concern about the development of technologies that can pose a challenge to existing tool sets. Some participants recognised a need to linger or hold onto obsolete workflows as common practice, firstly because of the knowledge needed to upgrade and secondly because some grounding was deemed necessary to stabilise a practice within a professional domain.

> *We all have software I think we don't upgrade, because we like the one we're using and it does what we require it to do. Also, it can become about…I suppose the thing of invention is the software itself, as opposed to the purpose of the software. And that's really where we would like progress to be. Painting lecturer, over 60. Workshop D.*

Two of the groups discussed the role of programmers and software design as part of the limitations that digital tools impose to digitally mediated creative practices. This echoes Dormer's perception of "distributed Knowledge" by which the users of an specific technology or software produce similar results (Dormer, 1997b, p. 139)However, in this particular case the discussion was sparked while handling one of the pieces created through WEAR3D, which challenged the notion of 3D printing as it was conceived by its creators, modifying its behaviour and "perverting it into producing results that would horrify the original designer" (Sporton, 2015, p. 4)

> *Designer/craft, 40-50: But you still work within the framework of the programme on the computer. You are still constrained by what the computer asks for in terms of the software itself. Whereas if you've got clay you can add wood to the clay or you can melt it down and dissolve it. You can not do anything outside of the program*
>
> *Ceramist, 50-60: I think you maybe right. You are determined by whatever the person or the people that thought the scope of the thing up in the first place.*

For these participants, the use of hand tools allowed more affordances and expressive freedom than the use of digital workflows. This conversation was followed by a debate about the need for control and risk over the creative process, this will be further examined in the discussion.

The different age groups of this workshops created a dynamic in which the value of the digital tool was constantly debated. For younger participants, narrative was implicit in the use of digital technologies. Whereas, staff members were more analytical and critical, feeling that "it was just another change" that had to be explored and developed within existing practices.

Thus, not being enchanted by the social factors that surround technical processes (Gell, 1999)

4.8. ROUND 3 AND 4 (G,H, I, J, K)

This round was mainly dominated by students. One of the most salient observations compared with the other rounds of workshops is the casual approach towards technology; there was no perceived difference between digitally mediated workflows and analogue tools. The divide that was explored in previous discussions was deemed redundant by the younger participants of this set of workshops.

> *Is it that important? I am post digital [jokingly] Labels are there to be explored and broken. Finding a language or… way out for your internal dialogue, the means, digital or analogue are not as important. I think most of us [referring to the group in the workshop] share the idea that is just a matter of integrating technology with other tools. Art student,20-30, Workshop G.*

Drawing games provided a great opportunity for adding dynamism and collaboration among participants. Additionally, the level of complexity of designs increased, the learning seemed to be improved thanks to the use of clear objectives. According to Kolb learning, and especially among professionals and mature students is more effective when it is objective driven (Kolb,2014). Figure 4-53 below portrays a collaborative drawing exercise and its collaborative digital representation. Participants achieved a great level of similarity when given the task of replicating the objects created through collaborative drawing, additionally, these models were of high printability and were ready to be printed without further adjustments. For this exercise, a participant folded a paper in three and started a drawing, stretching two lines over the fold of the page, then the following participant sketched with those two lines as a reference point. The figure below shows an example of one of the drawings, figures Figure 4-54 and Figure 4-55 show the original drawing and the result of the digital interpretation.

Figure 4-53-Collective drawing.

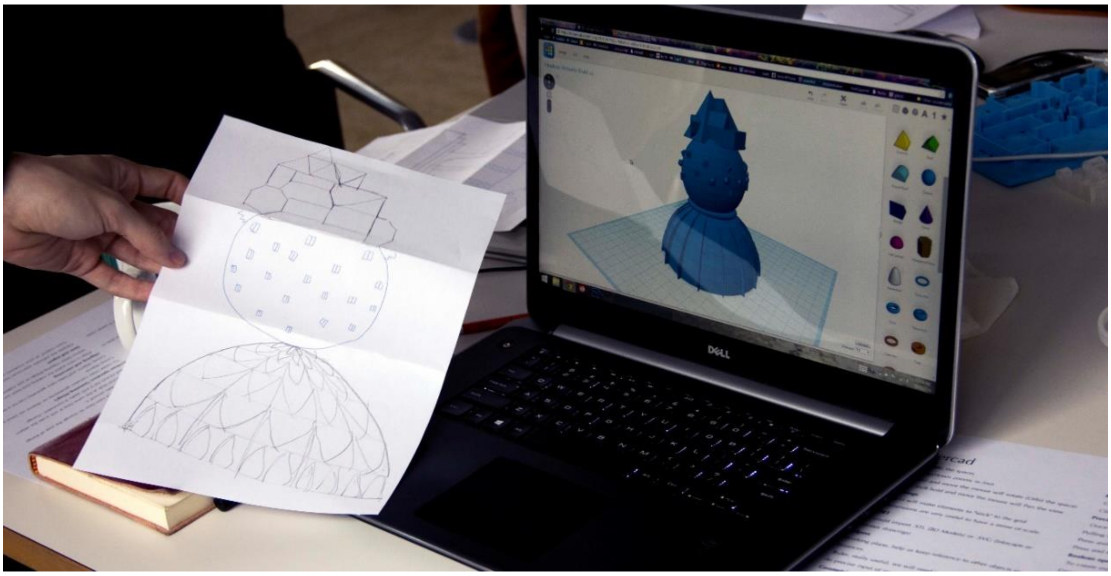


Figure 4-54-Collective drawing and digital interpretation.

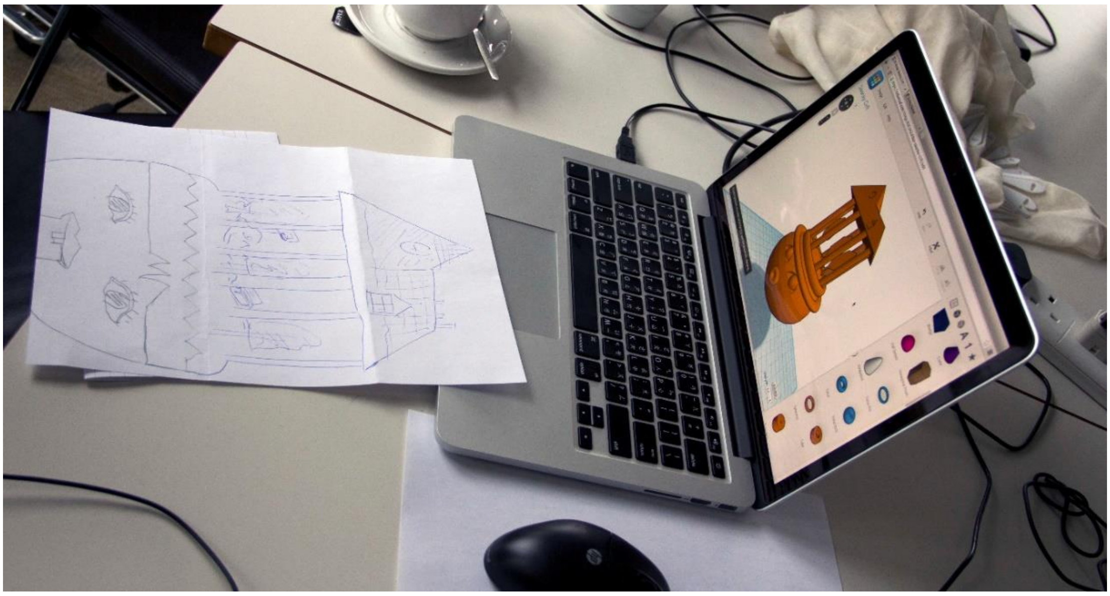


Figure 4-55-Collective drawing and digital interpretation, group b.

Workshops J and K were the most balanced in participation from students and professionals. These workshops were organised at the beginning of the following academic year (2014-2015), mass media publications about 3D printing had evolved and the narrative was not focused in disruption as much as the overhyped early stages of media coverage. This was patent in the way participants approached the workshops. Participants expectations were more realistic and often had deeper understanding of the relation of 3D printing with digital fabrication processes. Additionally, many of them have had prior experience with 3D modelling. Thus, the workshops focused on the use of supporting technologies and processes. The use of vector files was common and the workshop dedicated to 3D scanners was mostly focused on being provocative and playful around 3D printing. The figures below show the setup of the workshop and set up for scanning small elements with the aid of an articulated modelling table.

Figure 4-56-Workshop set up.

Figure 4-57-Scanning set up.

Discussions focused on the notion of the handmade, as well as the role of the tool and digital tools within creative processes. Participants discussed at length the limitations of emerging technologies and the heritage that those technologies have as a part of an existing set of processes. Based on the shared perception of technology being evolutionary, participants expressed their perception of emerging digital fabrication tools as part of a tool set that flows and adapts to trends and technological flows.

> *It seems to me with student photographers and myself you transpose your analogue skills into digital. I have no idea what it might be like to start up digitally; which most people do these days. But the best people working digitally are those who are the best working with analogue. Photography lecturer, 50-60 age group.*

> *That's only if you have the frame of judgement of an analogue perspective. We are faced with this challenge of trying to re-understand what it is we're doing. Musician and lecturer, 30-40, Workshop J.*

Which posed a challenge to understand what is the impact of new practices and emerging forms of creativity. For participants, the use of digital photography fostered the displacement of attention from the act of selecting the image and capturing *in vivo* to the skills of curating and editing;

> *Yeah or it just changes some other aspects of the whole thing. So if you take 500 photographs then the process is not to do with taking photographs anymore, but to do with selection, storing and so on. So the emphasis of where the artfulness and the skill changes its position in the process. But it doesn't necessarily mean those things of skill and care disappear, they just move from one place to another. Musician and lecturer, 30-40 age group.*

The view of this participant brings to the front of the discussion one of the key points of this thesis; what are the implications of an increasingly digitalised work environment within creative practices where the role of the hand or physical labour might be displaced?

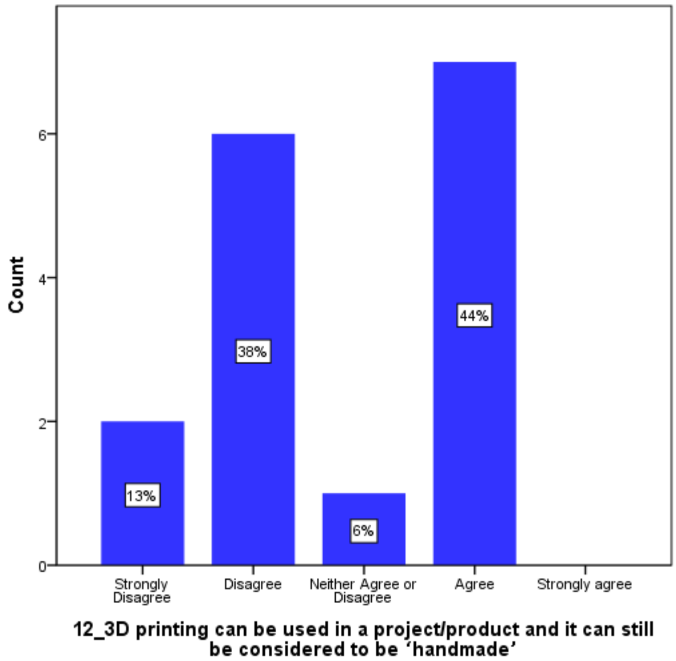


Figure 4-58-3D printing can be used in a project/product and it can still be considered to be 'handmade'

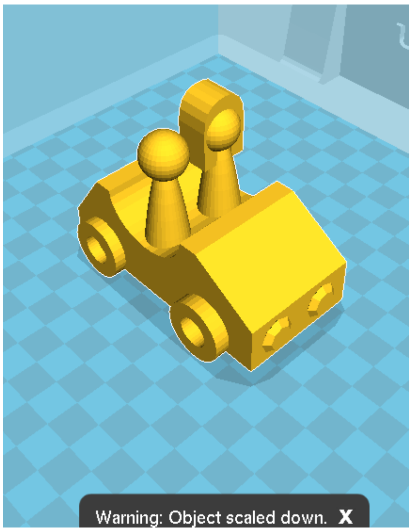
As we can see in figure 4-58 there was division in the perception of the role of 3D printing within handmade objects. However, the more seasoned participants discussed the prevalence of narrative over process and medium, although, there was some minor disagreement, the message was considered the most important aspect of a creative output, however, the participants mentioned Marshall McLuhan's theories during the day and quoted back during the discussion. Accordingly, it was defended that the medium was the message and that new technologies enable the negotiation of new forms of expression. However, the addition of a new technology within a creative process should not be given as a granted trait for originality and meaning.

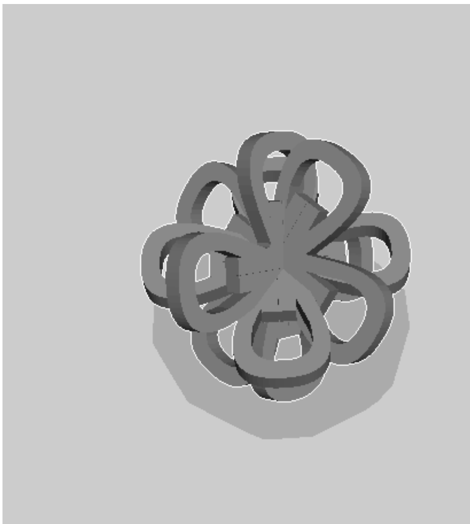
> *Absolutely, it is the managing of form and content […] It isn't just about ideas regardless of the medium. The form is the content. And that would be how this process [3D printing] for me would succeed in artistic terms, whether there is something more than lip service given to the way this thing is made; rather than there's the object. This [3D printed copy of vase] isn't a replacement for that [original vase made with clay], how can it be? For me it's just a non starter really. Photography lecturer, 50-60, Workshop J.*

In the discussions, the word "narrative" or the perception of *what is being told* dominated over the simplistic perception of technology as a goal. This resonates with Tavs Jorgensen research in the creative exploration of technology as means to human expression (Jorgensen, 2010).

> *I don't really see a great deal between one tool and the other [refereeing to digital design software and pointing at clay models on the table]. Although, I prefer analogue processes I focus on the outcome and how it can be produced in the best possible way. In animation, we are story driven and that is what drives the process from my point of view. Animation lecturer, 30-40, Workshop G.*

Objects developed in round 3 were highly elaborate and were more purposeful. Participants moved away from keyrings and started experimenting with prototyping and making more complex objects as toys. Additionally, participants were more inclined to experiment with more 3D design workflows and mixing methods and tools such as importing images and vectors into Tinkercad.





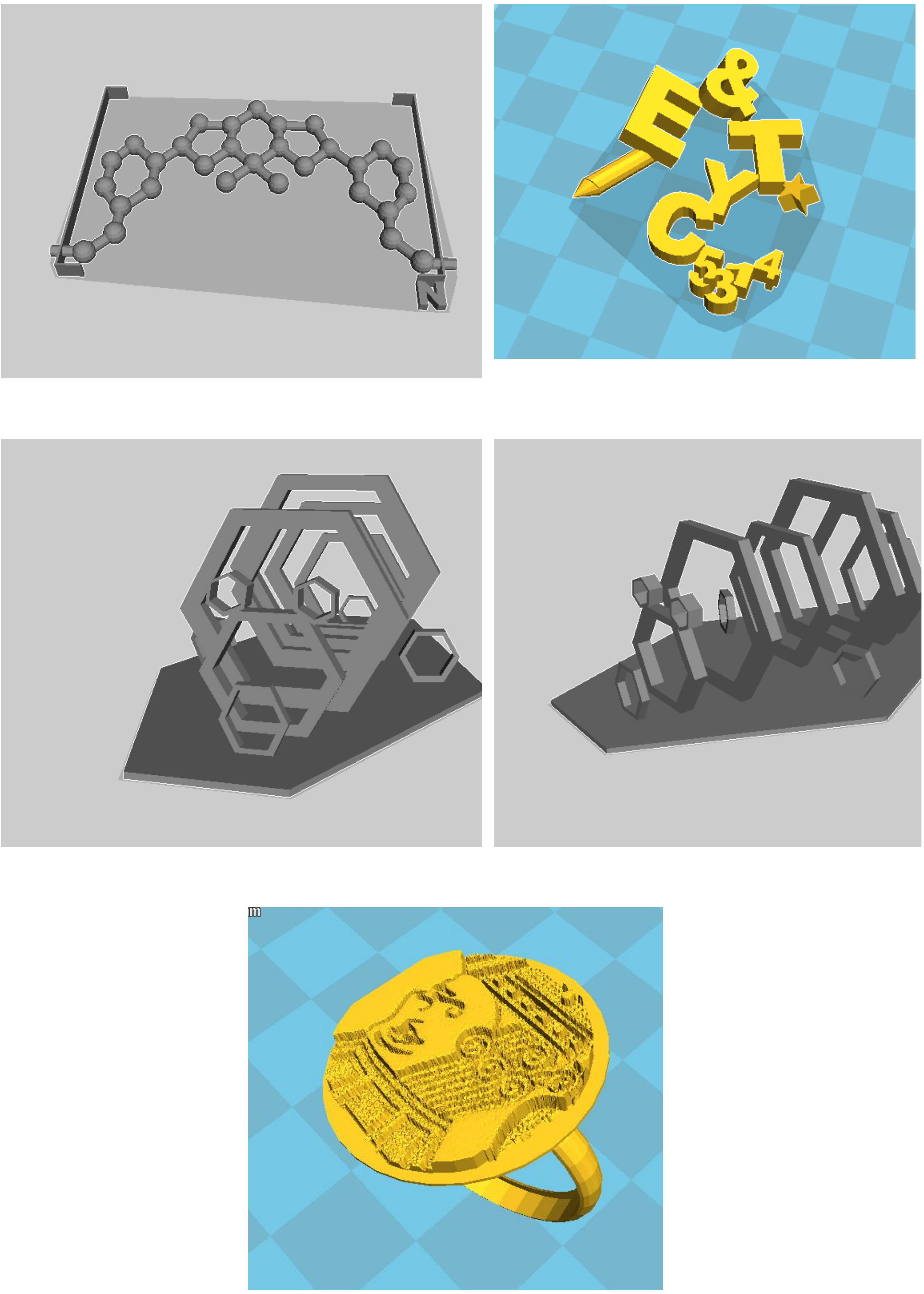


Figure 4-59-Final round, 3D models.

It is interesting to note that despite beeing more fluent in 3D modeling some of them still found diffulties to generate *printable* geometries. And to locate all the features of the models in space, this in many cases produced unprintable models, as seen in the image below.

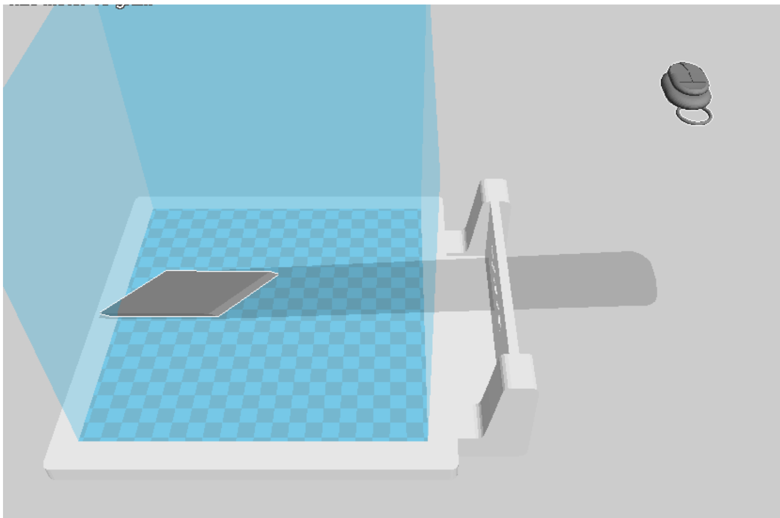
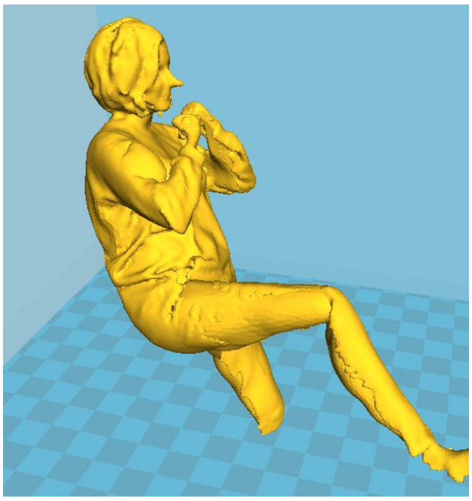


Figure 4-60-Unprintable geometry.

Round 4 focused on the experimentation with other processes, perhaps the most interesting aspect was playing with 3D scanners and the generation and alteration of geometries. In figure 4-36 we can see a participant who was scanned and then digitally *enhanced* with three-dimensional plastic surgery as a form of mockery after scanning her full body. Humour and exploration of the ability to dematerialise/digitalise anything gave birth to conversations, files and 3D prints.



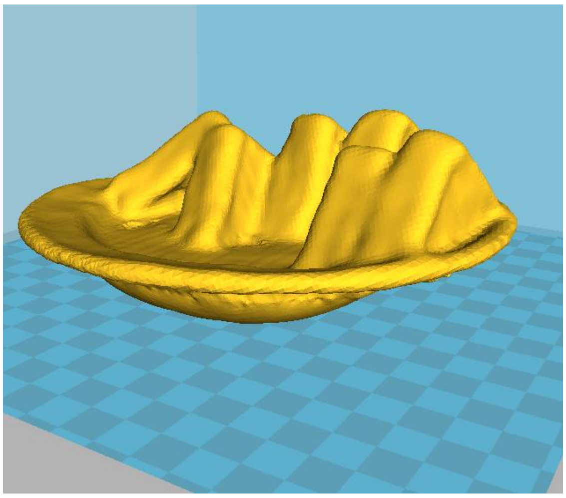


Figure 4-61-Playing with 3D scanners and appropriating objects and people.

4.9. SUMMARY

To summarise, the qualitative analysis of data confirmed the validity of the hypothesis extracted from the quantitative analysis through a factor analysis. However, some contradictions were identified and remained unsolved, the following points are then explored in the discussion after combining the qualitative and quantitative data from workshops with the results from interviews and collaborations.

The most relevant aspects covered in this chapter are;

> The identification of barriers and challenges for the adoption of a technology within a community of practice. These challenges can be classified as social, individual and institutional.
>
> The narrative dominated by mass media around emerging technology make practitioners believe that technology can pose a challenge to existing forms of making and its associated economy.
>
> This generates a perception of risk that challenges the perception of professionalism and labour.
>
> Practices that are considered traditional have an intimate and plastic relation with risk, the act of making is an act of discovery and chance, certainty is only associated with reproduction.

Perceptions and assumptions of 3D printing and its related processes were challenged through the activities set out in this chapter. Participants demonstrated a more realistic perception about the potential of the technology, and this is considered part of the process of domestication of technology (Silverstone, 1992).

One of the aims of this chapter was to identify the impact that the workshops had on its participants. The impact on participants from design and architecture disciplines with previous experience in 3D modelling was of particular interest. Participants from this cohort self-reported high levels of confidence using 3D design workflows, but the impact measurement did not perceive any difference in confidence between before and after workshops. Despite this, most of the participants self-reported increased confidence and a higher drive to further experiment with 3D printing. Although, as we have seen the expectations of 3D printing becoming ubiquitous within five years increased.

The approach towards content delivery and the use of blended learning enhanced the social aspect of learning (Tenenbaum, 2001, Brown, 1989) and the use of gamification and low-key mode of delivery contributed to the development of a safe environment in which participants were prepared to confront interpersonal risks when learning (Edmonson, 2003). However, the workshops identified several barriers, such as the lack of opportunities, the challenging characteristic of existing communities of practice on both sides (craft practitioners and technologists), gender issues and generational differences in the underlying digital processes (Loges & Jung, 2001).

The debates during the workshops mainly centred in discussing barriers for the adoption of 3D printing, this includes

-The need to manipulate physically materials to create objects

-The difficulty to bond with hands off processes (Treadaway ,2006)

-The lack of access to the technology, suitable installations or confronting gatekeeping and regulations.

-The inability to grasp some of the technical difficulties

-The perception of risk, both ways as a challenge to existing forms of practice and as a perception of putting at stake their own expertise.

Some of the early interactions proved that the older practitioners were generally less prone to experiment with emerging technologies, whereas the students and those with a less developed career were more prone to put their practice at stake by introducing a new technology in their workflow.

The definition of a low-level or easy-to-access workflow was central in the development of the workshop model, as well as simplifying communication with practitioners. ‘Bending technology’ came into being through iterative design, participant feedback and literature research. The premise for developing a low-level interaction approach towards collaboration derives from contemporary literature on modes of teaching and learning as well as knowledge sharing. Moreover, it is central within the scope of this thesis to explore and analyse traditional forms of localised knowledge sharing or creation.

Additionally, I recognised some of the participants were already talking about 3D printing as having the potential of becoming "just another tool" as far as a new language that is "true to its materiality" is possible. Thus, creating coherent narrative that is not driven by technology. Then the question is, how can we overcome the identified barriers to support the development of emerging narratives that nourish from the interaction with emerging technologies but are not driven by them?

Collaboration emerges as a possible solution to the digital literacy gap, additionally, mature participants reported more confidence in collaboration. Moreover, collaborations remove some of the risks associated with participating in experimental settings and the investment seems to be less risky.

Notions of collaboration were discussed and approached within the workshops, and direct observation of younger practitioners helping those from older generations was critical in the appreciation of a new way of learning together. The divide was in the perception of technology. Younger creative practitioners could define 3D printing as 'just another creative technology', whereas craft practitioners were not able to perceive it in the same way since they experienced barriers that needed to be overcome first. The debates around technology and the role of the hand and the tool in creative process developed further the perception of the role of 3D printing within creative communities.

Digital and analogue collaborations were explored to identify differences in the treatment of each other's creations. Digital files were not as respected as analogue outputs. The perception of physical and bodily investment seems to lead to better bonding and increased value of the experience of modelling objects, since hands-on and digital collaboration where timed equally this challenges the notion that expending more time adds emotional value to creations (Sennett, 2009). The definition of craft seems to be deeply related with the exertion of physical effort, although participants did agree that digital manufacture can be defined, in some cases, as a form of craft. The direct manipulation of material and the "kinetic" relation with materials and tools seems to prevail over hands off creativity. According to participants, craft is defined by the use of physical effort, the negotiation of risk and the ability to express oneself; to use David Pye's words, the "workmanship of risk" (Pye, 1978).

The discussions and feedback address the role of the HEI in the critical exploration of emerging technologies. Students consistently identified the inadequacy of the existing models since they tend to limit access and experimental opportunities. Additionally, they found the opportunity to collaborate with someone who was a professional within their field as an enriching opportunity. According to their feedback, this type of collaboration and working with emerging technologies should be included in the teaching agenda of any innovative institution. Offering space and time to play and experiment with innovative processes is leading certain institutions and schools to be at the front of technological development, as well as contributing to the creation of innovative processes and methodologies. PRINT3D, has achieved to communicate and expand 3D printing within the creative community of ECA.

During the summer of 2014 I decided to create a cross-disciplinary research group, called Raft. Raft capitalised on the knowledge acquired through the workshops as well as the contacts and experiments derived from PRINT3D. I chaired Raft until January 2017.

5. BENDING TECHNOLOGY; FOLLOW-UP COLLABORATIONS.

The approach that I have presented in this thesis as *Bending technology* addresses a way of understanding and working with technology that is rooted on different modalities of learning and exchanging technology, mainly in the proposed approach by David Hawking's; "messing about" as well as critical play approaches (Flanagan, 2013; Gauntlett, 2017). Dr. Matt Ratto, applied similar concepts of critical play for the exploration of technology within a learning and prototyping environment to develop his critical making series (Ratto, 2011). Bending technology nourishes from these approaches and perceptions of technology. The study of collaborations is framed within a blended learning approach (Heinze and Procter, 2004) with addition to the research on collaborations and digital technologies by Edmons et al. (Candy and Edmonds, 2010b; Edmonds et al., 2005) Additionally, I draw from circuit bending[50] (Ghazala, 2005; Hertz and Parikka, 2012) to form a proposition of simplified and re-appropriated technology as a way of facilitating learning of emerging digital fabrication tools.

However, in the identification of these ways of working around technology it became apparent that there is a lot at stake in creative collaborations, from the risk of losing control of the creative process to putting skill and practice at stake (Felcey et al., 2013). Hence, the objective of this chapter is to introduce the development of longitudinal collaborations as a complementary activity to the more lead heavy activities of the workshops; where my role was defined as a leader and had to facilitate more actively. In contrast, the longitudinal activities offer a flexible approach towards technological exploration and towards creative collaboration. Approximating this approach to what it would be described as 'adhodicism'[51] by Jencks (Jencks and Silver, 2013) but more in line to what seems to happen in creative exploration of technologies, the process of experimentation is followed by reflection and reiteration (Edmonds et al., 2005) but often guided by creative intuition (Philpott, 2012) and

[50] Circuit bending is a low-level hacking practice in which recycled circuits are modified into musical instruments.

[51] In its full meaning of a postmodern approach towards architecture, trying to reach to the needs of the local community.

leading to advance technical knowledge and intimate relationships with the technology at hands (Taylor and Townsend, 2014).

In the graph below the relation of collaborations during this PhD are shown with the outcomes and a basic description. However, I focus this chapter on the most prominent case studies.

Participant	Description of collaboration	Outputs/outcomes	Time frame, status at time of writing, 2017.
JD, embroiderer	Textiles, exploration of 3D printing within embroidery	Three different art projects and exhibitions.	Finished. Possible further collaborations.
MC, painter	Nottobereproduced, exploration of painting and 3D printing	One funded residency, and three exhibitions. Course proposal; *Monsters and misfits (ECA)*	Paused, intention to develop further.
MO, textile designer	WEAR3D, exploration of a method for 3D printing into textiles.	Three exhibitions.	In development. Seeking funding for further research.
MP, musician	Exploration of the design of geometrical soundscapes.	A collection of objects and sound recordings. Used in a public performance.	Finished. New project starting in 2018.
PN, jeweller	Exploration of processes to speed up production within jewellery and silversmith design and production.	A few meetings, nothing conclusive.	Undeveloped.
LB, textile entrepreneur	Exploration of organic fabrics and 3D printing.	1st prize Launch.ed Business Ideas Competition, 2014. Highly commended entry; Fresh Ideas Competition. Scottish Institute for Enterprise (SIE) 2015.	In development. Still in research stage.
JK, glass designer	Exploration of low level clay and glass jetting using a 3D printer.	Some experimental glass pieces.	Paused. Intention to develop further.
SF, textile designer	Exploration of expressivity and gesture mediated	Concepts for experimentation.	Undeveloped.

	through 3D printing. How to make 3D printing more emotionally appealing.		
EK, Forensic Anthropology department, University of Edinburgh.	Production of learning props and speeding of facial reconstruction process.	Range of practical outputs and publications.	Developing, applying for funding for further research.
MM, graphic designer	Learning props for developing type face skills.	Digital models intended to be used as teaching aids.	In development.

Table 5-1-Collaborations; outcomes and status.

5.1. BENDING TECHNOLOGY; CONSOLIDATION THROUGH COLLABORATION

The aim of this chapter is to give an account of three different interactions with practitioners that were carried during my research, although there were many other, the creative explorations presented here are the ones that lasted longest and produced deeper interaction levels. These case studies are an exploration on textiles and 3d printing mechanics, a development of pieces for embroidery and a collaboration with a painter.

With the purpose of grounding this research within local communities of practice I approached individuals and groups across Scotland. This created a very interesting environment for discussing and addressing issues identified during research activities. Additionally, given that the workshops, the collaborations and teaching in the university overlapped over a lengthy period, I brought experiences from the different activities to enrich and bolster the creative outcome of all the projects.

As described before, the overall way of engaging with participants consisted of two main activities; workshops and one to one experiments, presented here as case studies or longitudinal collaborations. Given the different nature of the interactions the results of case studies and workshops are presented separately. In some of the cases the results from the workshops informed the practices and experiments developed in the case studies. And often, the results of the one to one experiments were very good examples to be used in the workshops as props for discussions. However, from the research perspective, longitudinal collaborations were used as a testing ground and a way of triangulation of the issues and discussions started during workshops.

Identifying a meaningful, yet engaging, way of interaction with practitioners seemed to be more challenging than just running workshops. One to one interactions took far more time to develop. My personal approach towards working with individuals was very organic letting them develop at their own pace and make their own decisions. Social pressure and technological curiosity may or may not be present in their practice, however by letting them develop it at their own pace I allow them to find their own routes and meaningful ways of expressing and presenting their curiosity.

5.2. ORIGINAL BARRIERS AND ADAPTATIONS, DEFINING THE BASICS OF *BENDING TECHNOLOGY*

Meeting the technologists

My original plan of establishing a relation between two communities of practice; *hackers* and *crafters,* ended abruptly as soon as I approached the first group. I started communicating with a well-known hacker space in Edinburgh with the intention of talking about research, 3D printing and the possibilities of establishing a link with a group of keen craft practitioners.

However, they were dismissive and uninterested about 3D printing. Most of them had experimented with the technology and did not fall into the hype as perhaps I had done myself. At that point, the Edinburgh Hacklab did not have an operative printer, or they were not sure if it was operative. However, they were very supportive and aided my early experiments with a printer that came available. They did provide some guidance on how to solve some technical issues. The members I managed to meet from the Hacklab were more interested in software and other digital fabrication technologies rather than 3D printing. One year later, a couple of members highlighted the fact the Edinburgh Hacklab was one of the few in the UK to lack a working 3D printer, then they proceeded to acquire one.

The rejection of 3D printing is not a surprise, especially when it comes to analyse the ethics of hacker spaces and the hacker ethics. Most of them had already *played* with a 3D printer when I first approached them. The contraption seemed to be too simple and required extensive tinkering to keep it in working order. I do believe, as well, that they had other means to satisfy their fabrication needs by using a laser cutter or a CNC milling machine, both faster and more precise than any of the entry level 3D printing machines available at the time. According to Tim Jordan, hackers are often at fringes of cultural ebbs and specially rejecting hype (Jordan, 2008), when I started this research the Hacklab was receiving many inquiries about 3D printing which could have caused their rejection.

After finding this first barrier and trying in several occasions to engage with the Hacklab I decided to take a slightly different approach, I decided to become the technologist in the equation acting as a facilitator for the experiments and learning of others, this allowed to reflect on my own practice and develop more work without needing the interaction of bigger groups.

Meeting the makers

When I first approached a group of craft practitioners, I talked about emerging technologies and 3D printing, they were prone to reject it or be afraid of the possible impact of such a technology if widely disseminated (see section 4.4, perception of 3D printing pg. 88). This second barrier, was more easily overcome than the first. The confrontation of the myth created by the hype and mass media, was not easy, but it was overcome by offering opportunities to experiment in a safe and supportive environment. However, finding 3D printing useful within a well-established practice seemed to be far more challenging, this helped defining the frame for the individual experiments that are presented in this chapter.

Additionally, the language I used seemed to create some extra barriers. This was not only caused by the academic and research talk. When I mentioned hacking and coding, the older practitioners felt that there were extra limitations been raised (See diary entry Diary entry OLEUS workshop). Hence the second adaptation on my approach: I decided not to hack and/or code, or at least not in the most common way. Thereby I started *bending* technology; bending is the use of technology in a way that is not meant to be used; exploiting the affordances or exploring new territory without the need of actively changing the *guts* of the machine at hands. I appropriated this term from the existing trend of Circuit-bending. This term originally coined by Reed Ghazala, represents the action of using simple and low voltage circuits to produce experimental music instruments (Ghazala, 2005; Tadhg, 2010).

Pedagogical rationale

The ethos behind the experiments is based in my approach towards teaching and knowledge exchange and creation, I always try to level up with whoever is engaging with me in these activities, so they migrate from a participant or student position to a partner or a collaborator role. Trying to dim the relations of power established in a collaboration is crucial to develop an adequate environment for *experimental play* (Flanagan, 2013; Gauntlett, 2017). This approach allows for un-inhibited exploration of possibilities and solutions that otherwise would not be considered (Philpott, 2012). As defined in the methods chapter, Participatory Action Research is instrumental in the definition of this approach and marks the premises of the experimentation that I carried during my doctoral research. However, the excess of flexibility on outcomes at some point left me feeling as I had a partial lack of an agenda and gave the experiments portrayed in this chapter a differing feel from mainstream PAR approaches.

According to Jordan hacking is an activity that feeds and is fed by modifying technological determinism, to him, technology is ingrained in society in a way that doesn't allow for technology specific studies. He uses this as a premise for defining hacking as a creative activity that counters the determinism established or being generated by emerging technologies (Jordan, 2008). This is the opportunity I wanted to offer to my participants and collaborators, however, as described before, I had to identify an alternative way of positioning myself as an expert or technical advisor. My interaction and development of tacit knowledge with the printers brought me closer to the definition by Jane Taylor and Katherine Townsend of the 'technical designer'.

Through the experiments with individuals I tried to maintain a creative approach that demystified and clarified the opportunities that 3D printing could bring to the creative studio, however, this could be applied to any future technology that might have an impact in *digital creativity.*

Given the experiences and issues raised during the workshops, the collaborative agenda that pre-empted the definition of *bending technology* was established under the following observations based on discussions and literature:

- Move away from academic and media narratives and vocabulary

- Don’t assume technology equals progress (Sporton, 2015; Wyatt, 1999)
- Confront and challenge media narratives
- Hacking and *bending* are a creative way of exploiting transgressing technological constraints (Jordan, 2008; Levy, 1984; Sporton, 2015)
- Do not let the medium/technology lead the creative narrative (Myerson, 1997; Sennett, 2009)
- Create an environment that fosters creative exploration and with a “bias towards action”
- Individualize the experience when possible
- learn and adapt to the capacities of the practitioners and participants
- Allow “fooling around” and self-pacing of participants
- Stablish a dynamic that avoids being dismissive of traditional ways of making and crafts

5.3. LONGITUDINAL COLLABORATIONS

Through these collaborations I pay special attention to the concept of technological domestication as described by Silverstone (Silverstone et al., 2003) However, as we will discuss later, the scope of my research aims at unravelling the processes and strategies adopted by individuals and communities of practice to *domesticate* emerging digital fabrication technologies within creative practices. One of the main influences in this work is the research and practice of textile designer Philpott (Philpott, 2012), her work is an admirable example of how technologies, laser cutting in this case, can make the studio based practitioner more competitive in the current economy as well as a driver of innovation. Her approach towards CAD/CAM processes “entwined” with hand making contributed to simplifying and making more accessible a complexity that would have been unattainable to her as a studio artist. Philpott defends digital fabrication technologies and CAD/CAM, as they bring the practitioner closer to complex industrial processes. In her case creating digitally intricate origami patterns that were later transferred into textiles or the simplification of pleating thanks to laser cutting.

Drawing from Philpott’s approach combined with notions of *critical play* and the issues and suggestions made throughout workshops with creative practitioners, I set to develop further an understanding of the dynamics of technology mediated collaboration. Thus, *bending technology* was further elaborated alongside with original physical outcomes.

5.4. WEAR3D, 3D PRINTING AND TEXTILES

Figure 5-1-WEAR3D collaboration. PLA on fabrics.

WEAR3D: when desktop 3D printing meets fabrics. Participant: Female, age 27, independent artist, textile design.

This case study presents some of the findings and creative explorations of a collaborative project, in which I explored the possibilities of 3D printing with a focus on textile design and research. For this project, which we called WEAR3D[52], I collaborated with a textile designer and independent artist.

Our research produced a method for combining fabrics and 3D printing without requiring post processing. This method opens new fields for exploration and experimentation. With these techniques, any printable file has the capability of becoming a wearable. The ongoing research is contributing to the development and extension of the capacities of desktop 3D printing; new materials, new compatible fabrics or even the overcoming of the dimensional constraint of rather small 3D printers.

The initial investigation focused on existing fashion trends that were using the technology. However, the main trends use high level 3D printers to mimic fabric (e.g. Ditas' gown by

[52] more information and images can be found at https://wear3d.wordpress.com/

Francis Bitoni(2013)[53], Continiuum's N12 Bikini(2011)[54]) or approach it in a sculptural way (e.g. Iris Van Herpen: Crystallization, 2013). Contrary to what we could see, we wanted to explore the possibilities that consumer level 3D printing would offer in this context. With this project, we aimed at unlocking the possibilities that the technology could open to those interested in textiles and willing to experiment at home or in small studios, where entry level desktop 3D printers might be available.

With this case study, I aim at explaining the nature of the interdisciplinary research that was necessary to develop the printing method. As well as assessing, my role as a technology facilitator in the development of a new practice as well as my own and my collaborators practical skills. The research was done over the period of a year and most of the experiments were dedicated to the exploration of suitable fabrics that could merge with extruded plastic, more specifically Polylactic Acid (PLA), one of the most common and inexpensive materials for 3D printing. The experiments led to the development of a method that successfully amalgamated 3D printed material with natural fibre fabric.

Additionally, this case study contributes to the understanding of 3D printing as “just another creative tool” (Morvern, Interview, see annexe C) and the processes by which emerging technologies, 3D printing specifically, can be appropriated by a practitioner, approaching it with an experimental mind-set, moving away from the perception of 3D printing as *a black box* and a finite process that generates finished pieces, as promoted by the media.

Collaborator’s background

My collaborator is a textile designer; the emphasis of her work is in the movement and expressiveness of the fabric. Her experiments expose fabrics to natural elements such as wind and water, specifically, pervasive invisible flows to capture movement and flow. She grew up in an environment in which research and art experimentation were common. From an early age, she played computer games and has a very good level of computer literacy and digital design skills. She defines herself as a tinkerer and is inclined to making physical things.

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[53] http://studiobitonti.com/ditas-gown/

[54] http://www.continuumfashion.com/N12.php

Something that has driven her career; “a need to engage with the materials.” (Morvern, Interview, see annexe C).

When we met she had been learning about 3D printers through mass media, this had helped creating some unrealistic expectations that were discussed in our first meeting (July 2013, see Table 5-2,WEAR3D timeline.) As described before, the most common expectations are related with the technical limitations of the technology, like the speed of the process, normally they are believed to 3D print faster than what actually is feasible. Other misconceptions are the precision and the versatility of 3D printers, it is generally believed that 3D printers can reproduce anything. Morvern had read such things in mass media, however, her expectations were more focused on details that are normally given for granted, as for instance the shape of the extruders or the possibility of combining materials. This prompted interesting research strands that we could have taken. However, given our skills we decided to focus on using the technology as it was and exploit the possibilities that it offered without going through extensive hacking or *modding*, following the principles I devised for collaborations.

Context and rationale

Textiles and technology, an introduction

I decided to research the technological development of textiles to offer a context for two of the collaborations.

There are different theories about the origin of textiles and clothing, one of the most accepted theories places the origin of clothing around 170.000 years ago, this is based on the appearance of the body louse, which lives in the cloths (Kittler et al., 2003) There are different points through the history of clothing that have been defined as critical in the evolution of humans. Clothing as a technology has had a great impact in human evolution, to the extent that some theorists have defined some textile developments as critical industrial revolutions (Barber, 1993) According to Barber the invention of rope and threaded fibres was the first industrial revolution. Along with this point of view, many industrial revolution theorist have defined the invention of the Spinning jenny and other textile developments as key elements in the unravelling of labour displacement during the industrial revolution, thus, creating a mayor social and cultural swift (Allen, 2009; Engels and Díaz, 1976; Gragnolati et al., 2011).

However, underpinning this relation there is something deeper and very appealing for a technologist working with two textile artists, that is the perception of value and the personal relation with textiles, the emotional bonds as well as the perception of touch and feel of fabrics and clothing.

The relation of touch and fabrics has been in development since the emergence of clothing. Covering the skin, although mainly practical and for survival at the beginning is argued to have become a matter of status from a very early stage. Although the relation of touch with textiles is important for the development of the argument of this thesis, I will get back to that at a later section.

Textiles and clothing developments through history are deeply embeded with social meaning. Transforming the fabrics into a way of expression of emotion and status. Moreover, fabric is portrayed as a second skin in the way that is embodied and linked to our ways of feeling. Recent developments and research on emotional and intelligent fabrics offer an insight on how we are exploring some of the potential barriers and opportunities of fabric as a technology, rather than something we give for granted and that goes unseen.

The experiments that introduced in this section are relevant within this context as they are a way of approaching and challenging the way 3D printing is portrayed as a way of producing objects of design and prototypes, the two collaborations offer an opportunity to explore alternative ways of relating 3D printing to fashion, self-expression and a way of developing textiles and 3D printing hybrids that could open opportunities for smart wearables and alternative ways of attaching fabrics. Additionally, the third case study presents an exploration on the development of a gestalt on the use of a 3D printer beyond the stereotypical press and print. This I argue, fosters a deeper relationship with the printer that transforms it into a creative tool that moves away from the *workmanship of certainty* (Pye, 1978).

Strategy and collaboration lifecycle

The strategy I decided to follow in the case studies is represented in Figure 5-2, collaboration However, the organic nature of the interactions that I established with practitioners proved to be more challenging and dynamic than a straight line of stages. Each of the case studies seemed to follow a slightly different pattern. However, my overall approach is represented below.

WEAR3D timeline	
Met Morvern	May-13
First meeting about 3D printing	03/07/2013
Morvern uses the 3D printer for the first time	10/07/2013
First creative use of the printer	15/08/2013
First productive experiments	Nov-13
Consolidating processes	11/04/2014
First conference	Jul-14
Practitioner runs a workshop on 3D printing on her own	Oct-14

Table 5-2,WEAR3D timeline.

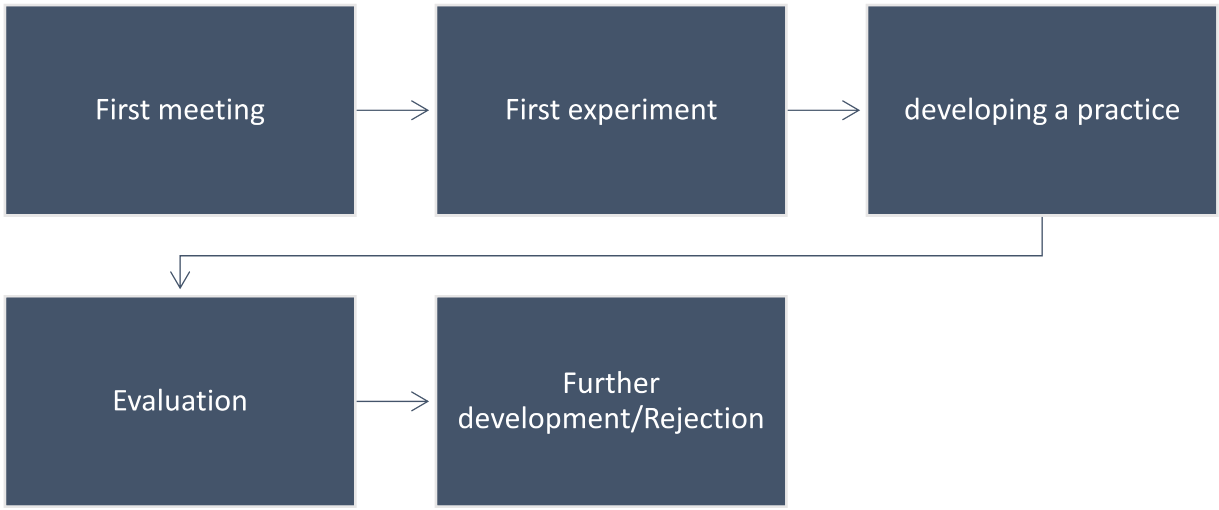

Figure 5-2, collaboration life cycle

Original idea

As shown in **Error! Reference source not found.** and Figure 4-6, page 75, the relation between workshops and case studies is demonstrated through the case study at hand, perhaps being the most successful in different ways. This collaboration emerged from the conversations and ideas that took place through most of the workshops and interactions with other groups and individuals, since it was the longest project under the scope of this research.

Some of the main influences for the development of WEAR3D emerged from the pilot workshop: OLEUS (see Zamora et al., 2013) For this workshop we recruited fifteen participants, half of them were designers, and the other half, craft practitioners. The discussions and activities were extremely helpful in defining further research and focus groups.

Some of the key findings have been highlighted in previous sections, however it is relevant to bring up two quotes that represent the initial spark for WEAR3D.

> *For me [3D printing] is just a process with potential to change. [...] Can I stop the process halfway and interfere with that process. For instance, this piece here [a small 3D printed cube] looks like a natural setting for a stone. Could I stop the process and stick a diamond in there and then let the process continue? (Jeweller, OLEUS workshop)*

This conversation made me realise that the needs of the practitioners were not being met by the technology as it was being marketed and that very specific experiments were required to see how far the limits of the technology could be pushed. WEAR3D represents this approach of distorting, manipulating and altering the *natural* process of 3D printing.

One of the participants of the pilot workshop, a ceramist, was less inclined to perceive 3D printing as a craft or even as a useful technology:

> *'I am not against technology at all. Every artist will need technology. [3D modelling and printing] is definitely art. But is it craft?' (ceramist, OLEUS workshop)*

Similarly to other participants of later workshops this represents the common opinion that, for something to be considered as craft, there needs to be a direct manipulation of the materials (Shillito, 2013). Although, as I will discuss later this might be impossible in other crafts as there is always some intermediate material or technology. Furthermore, both Pye (1978), acknowledges the use of technologies within traditional practices, referred as historical tools or technologies.

Experiments

During the experimental phase of this project we met at least once a week and worked for most of the day in each of the occasions. Sometimes we would work together sometimes I would leave Morvern working on the printer and textiles and only come back to make sure that the printers were operating properly and that she was not struggling with any part of the process.

The life cycle of the collaboration can be seen in the chart below.

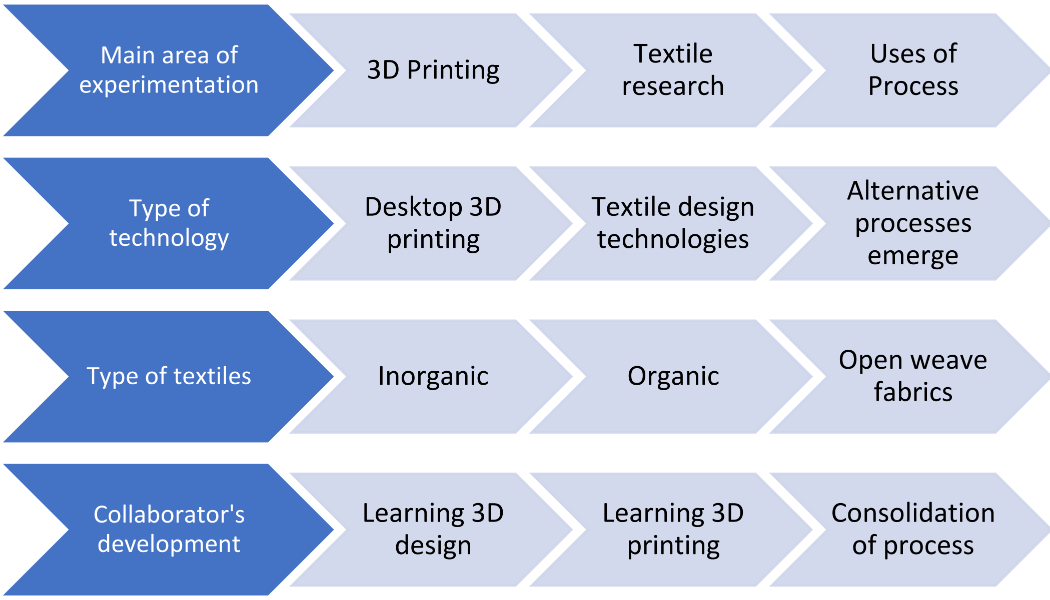

Figure 5-3, Strands of collaboration.

Phase 1; finding the textiles (July-October 2013)

Initially we decided to experiment with nylon and other polymer-based fabrics with the expectation of being able to melt them and then create a fusion between the extruded plastic and the material. However, this seemed to be a challenge that only managed to scorch some

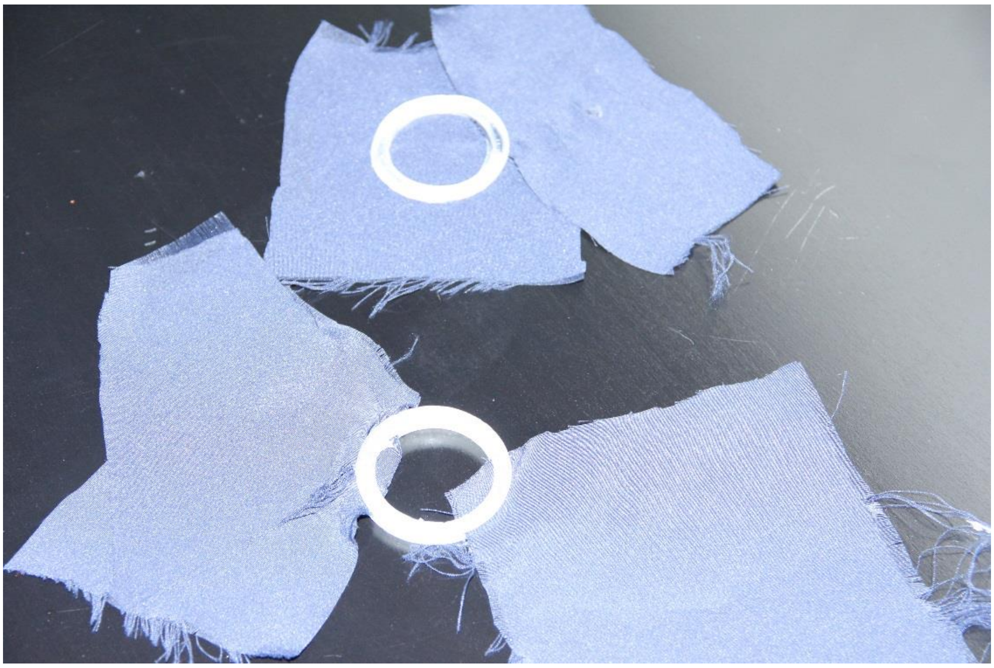

Figure 5-4-First experiment on trapping fabric with PLA, 2012.

meters of sailing fabrics and similar textiles. Early experiments led us to try ‘trapping’ part of the fabric with some of the geometry to be printed. This led to one of the first successful experiments, see figure5-5. Although, a success, we still wanted to find an alternative process that could offer a more reliable way of using 3D printing and textiles. The tests that we did on these pieces did not behave consistently and the process seemed to cast very different results under the same or very similar conditions. From this point, we started looking at different textiles, mainly focusing on open weave, but still using inorganic fabrics, as we expected that the high temperatures of the process would help the fusion of the materials. Figure 5-6, trapping fabric in textile with open mesh., Presents the results of the early experiments in this direction, but it took several months of experimentation to reach the next stage in the development of the process.

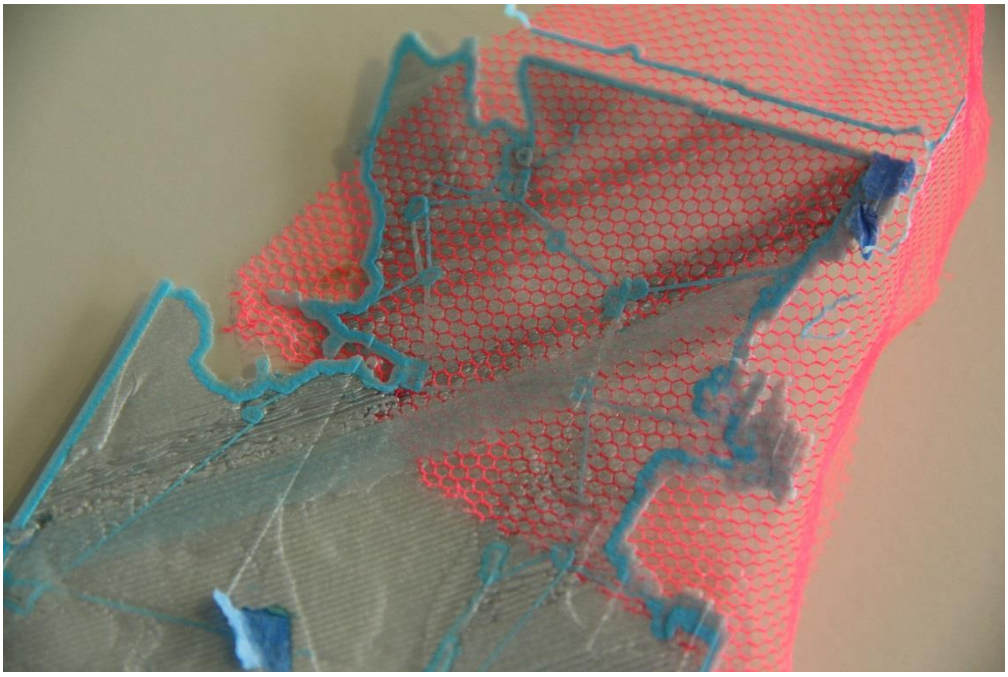

Figure 5-5, first experiment trapping an open weave with a 3D print, 2013.

Phase 2; first productive experiments

Once we discovered the opportunities that synthetic open weave fabric was opening we decided to start combining more pleasing and aesthetically interesting materials based on organic fibres like cotton and wool. From this point the process derived into two approaches that could be replicated by, virtually, anyone in the world that had access to an open frame 3D printer.

Process one; printing on top of an open weave fabric.

A critical part of the process of 3D printing depends on the successful adhesion of the first layers of the 3D prints to the building plate. Commonly a raft, or mesh, is built to make sure that the print gets a stable base to build up from. Based on this process we decided to place fabrics as the raft, hence creating an alternative process for 3D printing. Once the printer finishes printing the open weave fabric and the 3D print are interlocked by the same principle that unites the print to the raft.

Alternatively, the printing process can be paused at any given point, then place an open weave fabric between the geometry being printed and the nozzle and then resume the print. This interlocks the fabric inside the geometry being printed. This process offers more creative opportunities than the previous one and creates stronger bonding between the fabric and the 3D print.

In our case we used two different machines with two main settings for each of them which can be summarised in low quality and average speed and higher quality and very low speed.

The process consists of the following steps (this is introduced with images in the portfolio)

- Creating a geometry
- Defining printing parameters
- Starting the print
- Pausing the print at desired height
- Clamping of fabric to printing bed
- Resuming print to allow trapping of the fabric.

This process, although time consuming, allows the transformation of any given geometry into a wearable or an integral part of a fabric. Additionally, the binding of the plastic and the textile is very strong. See images of process below.

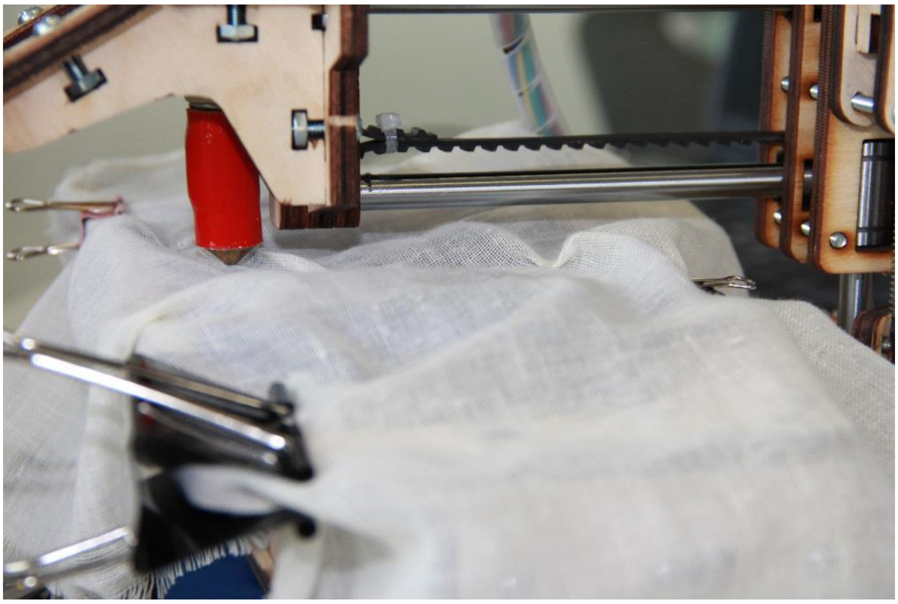

Figure 5-7, 3D printing onto open weave fabric, 2013.

Process two; heat bed transfer

After experimenting with this process, we identified an alternative way of transferring 3d prints into textiles. That is, using a heated plate, which is very common in textile design for transferring patterns and paint into textiles. However, we wanted to simplify the processes, so they would be more accessible, we tried to resolve it in a way that could be done with

Figure 5-8,PLA transferred into textiles using a household iron, 2013.

household items. Thus, using grease proof paper and a standard iron we managed to transfer 3D printed geometries into open weave textiles. This pieces where not as strongly bond to the fabric as the ones that trapped the textiles but certainly made it easier for other people to approach the process.

Impact

This collaboration served as a proving ground for interacting with practitioners within the domain of craft, it was the first long collaboration and the longest, this allowed me and my collaborator to develop a creative relationship that influenced our practices and that influenced the workshops I was running, eventually she managed to be using a 3D printer independently and she ran a 3D printing workshop on her own.

> "Now I am independent and I am happily printing away by myself. So if he were to ever do that again, he would know for all the people and help to understand and explain and I guess he has seen the direction the technology is headed in. A lot of it was just my designs, but I could have not made it without Diego and he has been talking with people and see what the reaction is, so I guess in research terms you have a thing to talk around rather than just to ask questions. and then I guess it opens up for the research questions." Morvern, interview.

We created a new process for 3D printing and developed our skills and knowledge, in my case in the field of textiles, for her the experience of 3D modelling and 3D printing seemed to offer an opportunity to go beyond two-dimensional design.

> *"I can now think in, more easily, three dimensions, it's definitely, the work I make with 3D printers now is more conceptual, that was one of the problems with my work, is more design or art work? but I couldn't do what I do now if I had not gone through the learning and also, I guess, slightly aside from the 3D printing, I am learning what an academic art or design route would be. Like Diego, I did one of the workshops and then I helped run one of them, it was interesting to see the research side of it." Morvern, interview.*

This is in many cases one of the biggest challenges when approaching 3D printing (Gershenfeld, 2007) She was offered a collaboration as a 3D designer shortly after one of the presentations we did. Additionally, she started gaining interest in academic circles and further formal research opportunities.

As a practitioner, she developed a tacit understanding of the process of 3D printing and moved away from the processes we developed to find a deeper narrative that would tie with her views on artistic production. Our process needed further development that was more aligned with engineering or fashion, something she was not interested in.

> *"I hope Diego meets someone who is more interested in that direction, Is not that I am not interested, but I am focused in the most conceptual side of it." Morvern, interview.*

One of the side effects of letting projects to develop at their own pace as an organic collaboration can be the lack of formal publication. Although I was actively trying to get the results of this collaboration published, we only managed to do a few exhibitions. This relatively low exposure led others appropriate the process.

Expanding limits of desktop 3D printing; being able to produce bigger pieces by running the fabric along or using fabric as the frame, and making 3D printing more valuable. This challenges the perceptions of previous participants who stated that the 3D printers couldn't satisfy their needs on scale or use of the final product.

Further development and possible uses

The method we developed has been adopted by several practitioners, one of the examples is a Master student from Edinburgh College of Art who used this approach to develop flexible fashion garments. Additionally, there is a trend of people development printing on textiles we are still working on expanding the range of textiles that can be used and in combination with other standard materials for fused deposition modelling.

As part of my collaboration with the Forensic Anthropology department of Edinburgh university we have started experimenting with structures that could be transferred to textiles to do research on stabbing and knife wounds (Johnson et al., 2013). There is some research in this area but without the application of textiles, we do believe that by using technical textiles the performances could be improved. Additionally, some projects that have evolved in this direction use 3D prints on textiles to create splints (Paterson et al., 2015).

5.5. 3D PRINTING EMBROIDERY

Jen Deschenes is a 39 years old embroiderer original from the Shetlands. We met twice before we started the collaboration, both in workshops that were related to making and design. The first meeting we held as part of our collaboration was on the 29/11/2013. Then it took a few months to get the creative activities started. Although she never invested time in developing her digital design skills we both benefited from the interaction. Working with the 3D printers and the material seemed to expand the perception she had of her own material-oriented practice.

Background

Jen was born and raised in Shetland, Scotland. She studied textile design and is specialised in screen printing and embroidery. She has a strong relation with her family traditions; sailing and life in fishing communities. Her practice relates to natural environments and organic forms and shapes. The core of her creations is the narrative of the intimate and nostalgic.

She defines hand drawing as one of the most important activities to develop her thinking and practice. However, she tries to bridge the use of antique fabrics and modernity through a process of re-appropriation. She makes everything by hand, which according to her contributes to the enhancement of the history of the fabric, her pieces are unique given the rarity of the fabrics and the artisanal process.

Context and rationale

When we met the first time it was in a creative workshop about making and textiles. The workshop was part of a scoping strategy for a project related to rural economies and craft. The second time, it was during an interdisciplinary residency as part of Naked Craft project. The conversations around digital fabrication captured her attention as 3D scanning and 3D printing could open a new opportunity for exploring the natural environment.

At the time of the first meeting I had just started working with another collaborator in WEAR3D Embroidery was the perfect complement as we were already exploring the combination of textiles and 3D prints. Her initial intention was to create 3Dimensional knots that could be used as beads in her embroidery, however the printers I could use, were not capable to create objects as intricate and precise as necessary for that purpose.

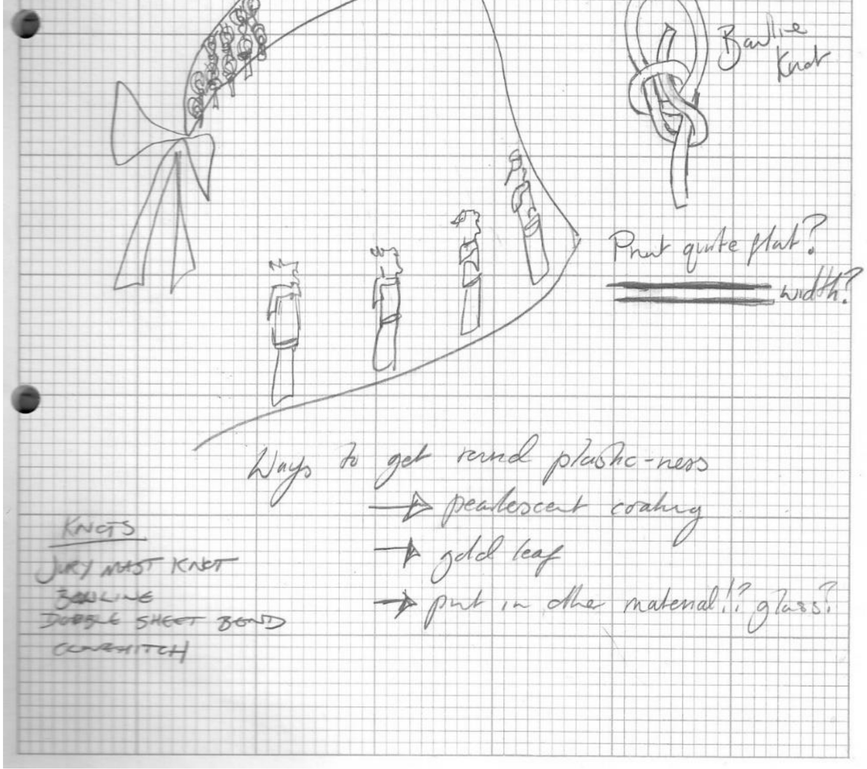

Figure 5-9-Draft of concept for 3D printed embroidery.

The other initial idea was to simplify or speed up part of the process by creating shapes that would ameliorate the amount of threading needed to create certain geometries with beads. By creating some cluster forms that could be used as a basic geometry.

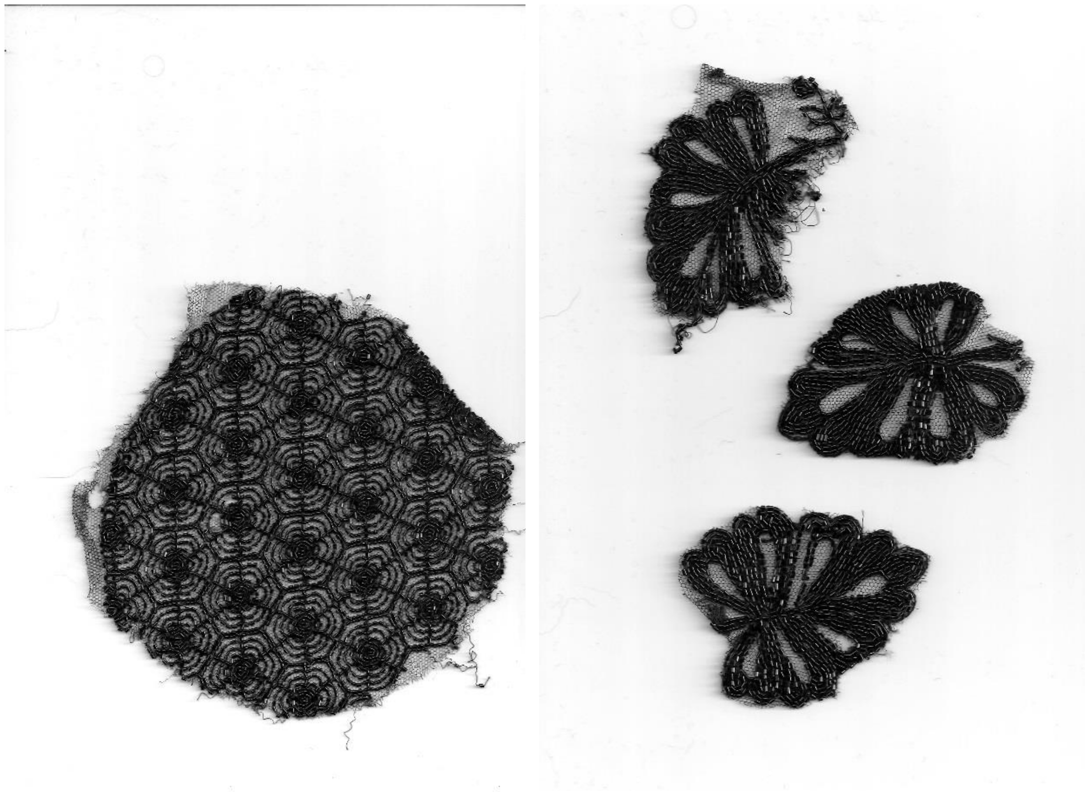

Figure 5-10-Images of embroidery for adaptation into digital pieces.

Method and planning

We never really got to fully collaborate as we were far from each other and we mainly interacted to evaluate prints and exchange some opinions about what could be made or not. At some point, I became a 3D printing service rather than an active collaborator.

We worked in two projects that were exhibited in two different venues. At the time of this writing (early 2017) she is still working with some of the 3D prints and has now created a new piece by using the by-products of some of the 3D prints.

Experiments

My personal experiments trying to reach the objects she wanted to create were all done using 3D design software. On the other hand, she did a lot of experimentation and exploration with the materials. As part of her developing narrative.

From pictures to geometric shapes, In her creative exploration drawing and images are critical to prototyping and planning. Hence, the beginning of our work was based on photography's of objects she had created, or organic shapes taken from nature. This was a challenge at first. To begin with there was no direct way of transforming an image into a geometry. The accessible processes I could concoct were meant for geometrical shapes. In many of the cases the shapes had to become very basic polygonal geometries, and then transformed into organic shapes. This added a level of creative experimentation. From geometric shapes to three dimensional organic shapes. (see portfolio for images of exhibitions)

Impact

Jen has adapted 3D printing to be part of the narrative around different projects. However, our interaction throughout this project was limited to me printing things for her to use as part of bigger pieces. This limited the interaction and she did not develop a deeper understanding of 3D printing. It is interesting to note how Jen perceived plastic as a valuable material, when compared to other craft practitioners.

> *"I don't know, I probably wouldn't unless I liked what it was saying. That's the thing: to do something you like the message from (rephrased - you must like the message you get from the material product). As opposed to just thinking of it as plastic. But I tend to work with really nice materials. Plastic is a funny thing though, it's really since the 50s it has gotten into everything and even with the stockings I do I like using old socks sometimes. They are not that great to wear to be honest, because if you wear them you have to wear them with suspenders to keep them up: they're worn like slouchy socks. But tights, it is the result of plastic that we can wear tights. It depends how you look at things doesn't it? Depends if you can adapt it, that's what I mean." Jen, interview*

Through this project Jen developed a better relationship with plastics. Through this collaboration her appreciation of the material and relation to the process increased. For me this project was the first encounter with a practitioner needs and challenges in the process of learning how to use and learn about digital fabrication tools. In her case the lack of previous experience and not being driven by curiosity the collaboration started with a different tone. At some point, she expressed her lack of interest in learning how to model or do 3D design. However, this presented an opportunity to explore what would be the relation that a practitioner would develop with something that she did not create directly. Her curiosity was focused on the material qualities rather than the process, she wanted to explore the medium as a complement to her existing process, rather than exploring or challenging the process that she was using already with the inclusion of a new technology.

5.6. NOTTOBEREPRODUCED

Mark Connolly

This case study explores the development of an art project; in comparison to the other projects the artistic aspect was the essence of the collaboration. I met my collaborator at an ICT ART connect event in Edinburgh on the 25/01/2014. The project aimed at connecting technologist and artist with the intention of developing new creative practices or conceptual art. We successfully applied for a funded residence (1.500 pounds) that culminated in an exhibition in Brussels and a presentation for the ICT commission of the European Parliament on the 12/05/2014.

In this case my role seemed to be well defined following the premises of the encounter and the selection of participants, I was meant to be the technologist that aided or collaborated with the artist in their pursuit of a more technologized art practice. Apparently, the practitioners diverged slightly from the agenda of the organisers, not everyone wanted to tie their practice to technology, but to rather solve some technicalities in their practices.

Background of collaborator

Mark is a painter and plastic artist, residing and studying in London. When we met, Mark was on the final stage of his painting degree in the Edinburgh College of Art. He had never worked with 3D printers or digital fabrication tools. His IT literacy was average for an art student of his age (early 20s) However, his digital design skills were relatively low compared to his colleagues. He was mainly interested in the traditional techniques of painting; hence digital design tools were not relevant for his practice.

Context and rationale

The collaboration was kick started thanks to a speed dating style event, thanks to this event we already had a range of concepts to explore. However, given that the time frame was four months, we decided to limit the exploratory stage and we set for hands on experimentation using a process he was already exploiting, we adapted it to a digital workflow as an approach for generating 3D models.

The labour intense process that we created aligned better with the craft of painting than with the idea of digital fabrication that he had prior to the experiments. This aspect seemed to increase his interest in developing digital design skills and further experimentation. The digital processes were not so remote from the idea of physical manipulation that he had encountered in his main medium of expression; oil on canvass.

As part of his creative process, Mark, was already using social networks and digital images as a generative tool. He appropriated images from others and distorted them to create "amalgamated stories of time and space" (Mark, painter) In Figure 5-11 Space 1, Oil on Canvass, 2014., you can appreciate the type of transformation that images were going through to create a new narrative.

Figure 5-11 Space 1, Oil on Canvass, 2014. By Mark Connolly.

Social media platforms are ubiquitous, we seem to take lightly the implications that the use of this networks can have in our life or the life of others. As an artist, Mark wanted to express his discomfort with the idea of sharing images that then get appropriated by the collective network. He wanted to challenge the idea of ownership and belonging through the appropriation and distortion of images.

With our final process, we envisage a functioning system stemming from the injection of others´ memories and experiences into the work via stolen pictures from social networks. We appropriate real-life situations to create an amalgamation of familiar, yet uncanny, sculptures. The pieces that we create give personal imagery a second chance to be reconfigured and reinterpreted. This afterlife reflects how we lose control over *shared* online content, be it images on social networks, 3D models in online repositories or digitalized art pieces

For this project, we merged several separate coexisting places into a printed plane to create a series of hybrid objects. Through the absorption of a multitude of places these objects form representations of condensed time. The overlapping and compressing of time and space is central to our collaborative investigation of 3D printing and painting. Rene Magrittes' works *´the key of ice´, 'time transfixed'* and *'Not to be reproduced'* offer plausible scenarios that are represented in a direct and concrete manner. We elaborated on his traditional approach whilst introducing them into 3D printed format.

The objects we present are the outcome of the experimentation with the limitations and affordances of the technology at hand. *Bending* instead of *hacking*, *appropriating* instead of *discarding*. We use the unfinished and the by-products of 3d printing as the main structure of our creations.

The exhibitions that we created within the scope of this project consisted of Fused Deposition Modelling (FDM) 3D prints of Polylactic Acid (PLA) and two Oil on canvas paintings.

Method and planning

Considering that his digital design skills were low I had to make some decisions as how to proceed with the project. I was fully committed running workshops at the same time and I couldn’t afford to do all the digital work. Hence, we agreed on developing a system by which we could both learn from each other’s practices and at the same time stay in tune with the amount of work that was needed. As a project that was part of my research I identified that the best way of adapting to his practice was to support his development as he explored the possibilities of 3D printing. However, he did not become autonomous in the use of the printers.

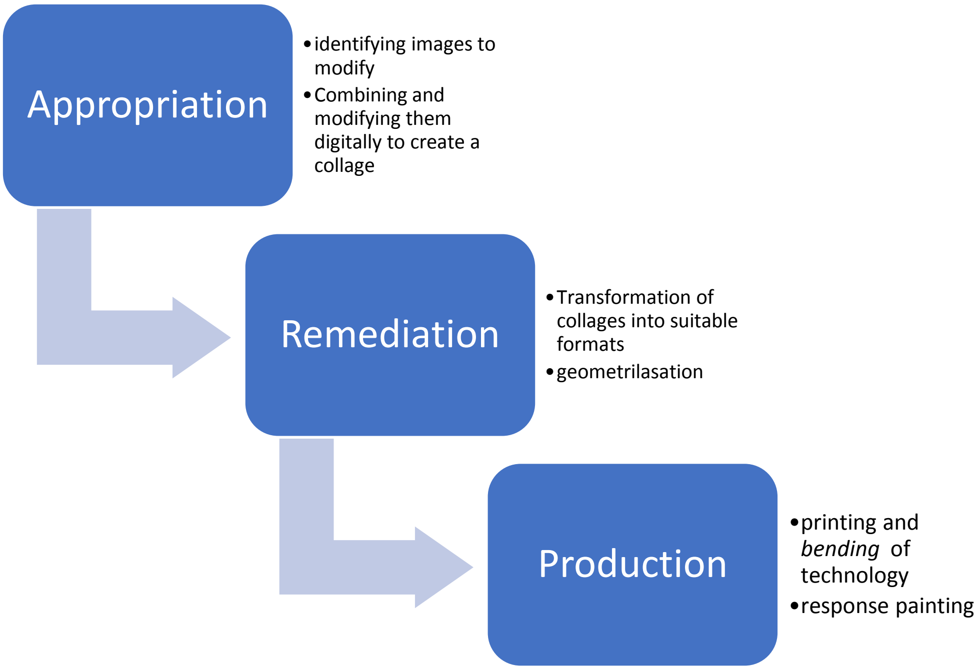

Figure 5-12, stages in appropriation of technology.

Experiments

Approach 1, 3D collages, Sense of space.

We used the process of appropriating digital images to create three dimensional collages. Below you can see the progression of experiments and how they gained in complexity. Within this process we decided to keep some of the by-products of 3D printing as part of the narrative, such as support material and scaffolding and the rafts that are used as support for the whole 3d printing.

Approach 2, errorful creations; monsters and misfits.

When we approached the 3D printer trying to produce our pieces we realised some of them were actually not feasible. Or at least, not optimised for printing. It was then when we started exploring the aesthetics and the process as a creative tool, thus making the act of 3d printing a critical part in our narrative. We had already started appreciating the support material as part of the narrative, however in this stage we started using it actively as a part of the productive process. We started manipulating the printer as it was printing to change how it behaved and to transform the prints.

Early experiments were focused on identifying how we could replace the colour of the feeder to create multicolour prints or different effects in the prints (something not very common on FDM prints)

After that we started exploring the relation of coloured support material and infill with thin layers of translucent filament. This created a very interesting effect that we decided to exploit in further experiments, however, given the how demanding the process was we didn't produce many pieces, each piece required to expend many hours observing and modifying interacting with the 3D printer. The amount of work and implication of the creator would make it very challenging to replicate the same piece, thus giving a sense of uniqueness to each creation.

Impact

We believe that 3D printing can be exploited and subverted to find alternative channels of expression. Our narrative thrives on the exploration of the unfinished and the by-products of the process. Unfinished prints, *errorful* creations and disrupted mechanical processes are central to our way of doing. We find the term "unfinished thinking" serving as a double-edged blade when applied to our research, both in the most strict meaning defined by (Borghoff and Chow, 2012) as well as an invitation into the distorted presence of our pieces. This set of mind gave birth to a course proposal that will be starting in 2018 in ECA, *monsters and misfits*, where students will explore creative processes within the fringes of disciplinary boundaries and the role fabrication techniques play in promoting this.

The exploration of relatively simple colours or colour schemes seemed to modify the perception of colour on Mark "now I don't seem to use as much colour and colour mixing as before" (personal communication) This has been influenced by the simplification that the images had to go through to be 3D printed. Mark was very interested in the monochromatic aspects of 3D printing, which seem s to have sparked a new area of exploration in his practice. Among other aspects that have been detailed earlier in this section, if we look at the figure 5-13 and figure 5-14, below, we can see how the physical manipulation of the 3D printer to create "unfinished" objects triggered a creative response in the form of a painting. Thus, offering the opportunity to develop a tacit understanding of the process of 3D printing.

Figure 5-13, structural exploration of a geometry. PLA, 2013.

Figure 5-14, response to structural exploration. Author; Marc Connolly, Oil on canvass. 2014.

Impact on my own practice

This case study opened new revenues of artistic exploration, before I was mainly focused on interacting with people whose craft was mainly physical and deeply related to materials.

Further development

The process of creating 3D collages inspired some other activities as the idea of using 3D puzzles as teaching aids for graphic designers. Additionally, we are looking at alternative ways of exploring this creative process with a mix media approach. Thus, combining the printed plastics and the paint.

5.7. ANALYSIS OF COLLABORATIONS

Relation between collaborations

As described before, my intention was to lead several experimental and evaluative sessions with the different practitioners. The different level of implication and willingness to directly experiment with the technology lead to the following general map of interactions. Figure 5-15, Collaboration road map. The collaborations presented in the case studies of this chapter led to the identification of three interaction models as represented in Figure 5-16, collaboration levels.

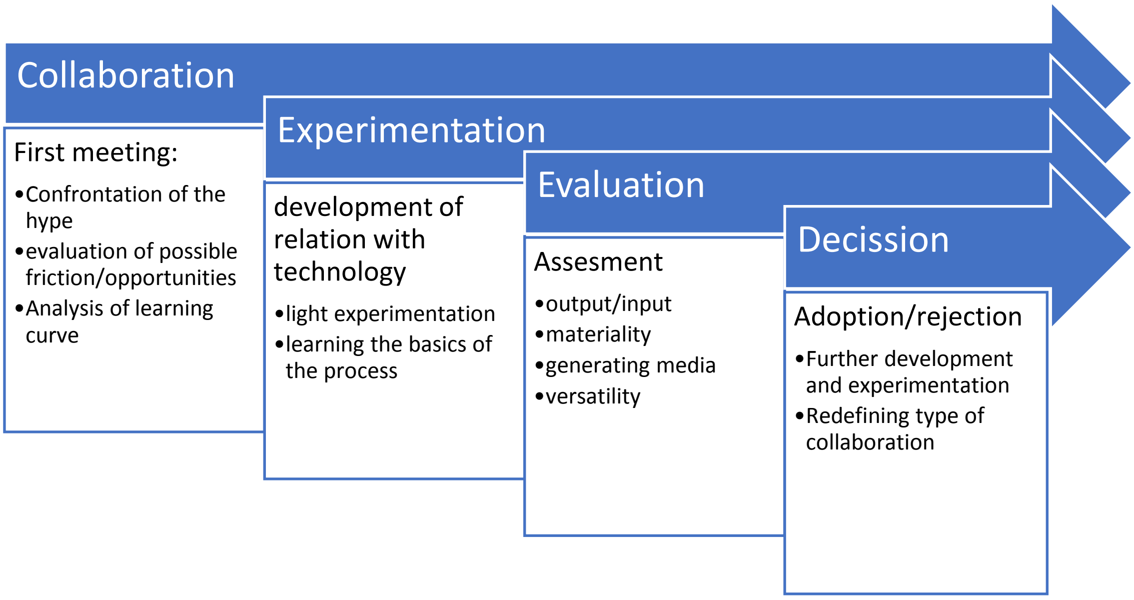

Figure 5-15, Collaboration road map.

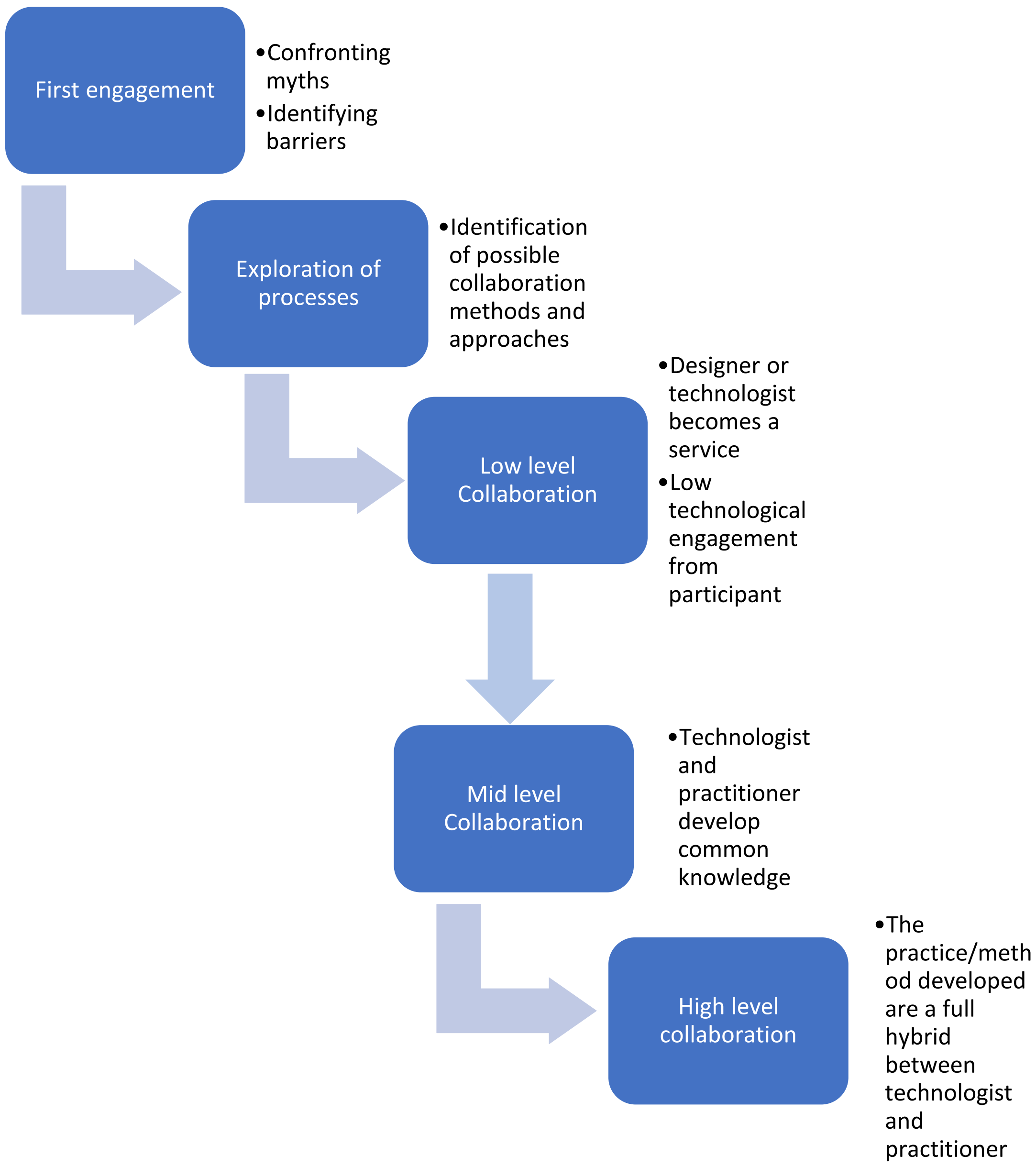

Figure 5-16, collaboration levels.

Traits	Morvern	Mark	Jen
Influenced by mass media	Yes	No	Yes
Established practitioner	No	No	Yes
Technologically knowledgeable	Yes	No	No
IT proficiency	High	Average	Low
Arts Education	Degree	Completing degree	Degree
Recently graduated	Yes	Yes	No
Economically independent through practice	No	No	Yes
Willing to learn the software	Yes	No	No
Using 3D printers after collaboration?	yes	No	yes

Table 5-3, relation of collaboration practitioners.

3D printing as a creative process

As defined before one of the main and primary activities when meeting the practitioners was to challenge the preconceptions about the technology. The three practitioners presented in this chapter developed a better understanding of the technology and moved away from over-hyped perceptions. Thus, developing certain criticality of the technology to the point of questioning its relevancy and usability.

> *"would be better modelling something out of clay than with the software and I think there always be some intuition thing, but there is a barrier" Morvern, Interview.*

This raises the issue already brought up in previous sections about supporting technologies and processes that are part of the workflow of 3D printing. Using *bending technology* approach, I proposed a simplified approach towards these supporting technologies, however, as we will discuss later, most practitioners still defended that direct material manipulation was easier than 3D modelling.

3D printing for supporting a narrative

Although differing in the levels of interaction, curiosity and knowledge, all three collaborators were driven by the need to identify a narrative that would represent the artist ethos;

> *"I hope that my work will challenge that, [the] idea that [3D printing] is not handmade, in that I really try to design for the material rather than against the material because I don't like plastic particularly, I try to see something more in the plastic rather than a printed model thing, trying to make it beautiful. […] I would hopefully make people think again about that idea that I just press the button and printed something for me because we are disrupting the print and trying to add things and make more than just a model." Morvern, interview.*

The representation of an idea primed over the use of a specific technology or material. Even if plastics were not considered as a craft material before the collaboration.

> *"I don't know; it depends what it says. If it fits within a narrative, expresses something you're trying to say and it can be made nicely then maybe, but I've never worked with plastics […] It is always the story someone has to say, as opposed to what it is made with. " Jen, interview.*

5.8. CONCLUSIONS.

The collaborations presented in this chapter have been defined by both flexibility and an experimental mind set. 3D printing was used as a tool for exchanging ideas and exploring creatively different media. This mindset tried to address the needs and queries that creative practitioners voiced during the activities of the workshops, presented in the previous chapter.

The conversations and focus groups during the workshops sparked a line of enquiry that tried to address the role of technology in creative collaborations. This was the onset of the experiments presented here, where we explored how far the limits of the technology could be pushed. WEAR3D and NOTTOBEREPRODUCED represents this approach of distorting, manipulating and altering the *natural* process of 3D printing.

The three collaborations share common ground beyond the use of 3D printing; there is my role as a researcher and supporter, as well as, the inclination towards technological disenchantment. Although 3D printing was what sparked the interactions, it was soon dismantled and reassessed as a potential tool into a broader practice, in some cases rejected, in others made better and merged into a meaningful narrative.

The three artists had a focus on narrative, rather than process, and never let 3D printing be the driver of the creative process. However, 3D printing was the central piece on the interactions, to some extent driving the dynamic of the collaborations. Thus, stablishing a power structure, where at some points I was the owner and gatekeeper of the technology. This I believe was challenged in the cases where there was a merging of practices.

As it has been highlighted before, age is reported to be a critical factor in the adoption of ICT (Loges and Jung, 2001; Prensky, 2009). This has been voiced by participants in this thesis. This chapter offers an example of the different inclination towards learning a new technical skill among practitioners, although the age of the collaborators verifies the typical argument of age being detrimental to computer literacy, we could not conclude with just three cases.

Even though it was acknowledged that technology could cause labour displacement; [with new technologies] *the things that were before done by hand and were time-consuming become defunct* (Jen Deschenes, interview) Emerging technologies and especially 3D printing were never seen as a threat to their practices as opposed to the perceptions of some workshop participants.

6. ON BECOMING A 3D PRINTER

One day taking notes about the activities that I had been running for a while and reflecting on a collaboration that was just starting I came to the realization that to some I had become a doorway to 3D printers, or even a 3D printer. I had developed relations that went beyond collaboration and some others in which I was just a technical service. Moreover, I had put my practice at stake, risking my knowledge and practical skills (Felcey et al., 2013, p. 1)This left me unsure of the terms of practice I could use to define myself. Indeed, in defending the critical use of technology - in deconstructing my practice to become one with my participants and with the technology at hands - I had lost my identity as a practitioner. This created a personal crisis of identity and I was forced to enquire whether I had become a 3D printing service, a designer, a creative friend, a craftsperson, a researcher or none of these.

What followed was an informal conversation with the director of my project, during which we discussed my involvement in the practice of others. She said I had to be bolder; more aggressive. Additionally, a project-wide review panel felt that my research lacked a relation to any specific discipline, some pulled towards art, design or even silversmithing. Perhaps they all saw the similarities that a participant pointed during the workshops when talking about 3D printing;

> *"It shares some stuff with casting, because you can make copies of something and that was the old technology to do something. All of us are coming in from different backgrounds and everyone is seeing how its very similar to what they do in one respect. I mean we all think it looks like textiles, its got a lot to do with photography and sculpture but it is all somewhere else as well." Workshop J.*

Perhaps I was too close to the technology so no one could tell the difference. Yet it is for this reason that I began the research - I sought to become *beyond discipline*. As a practitioner, I wanted to learn from the practice of others - to capture the essence of their practice and appropriate or *remediate* it with my own set of tools. Then, analyse the creative outcomes with my own eyes and critical mindset. The essence of my research is then cross disciplinary, and it challenges the unitary perception of discipline as suggested by Beegan and Atkinson, 2008. These reasons brought me to art school, and they define the way I *play* with emerging technologies: at some point, the "new becomes the old" and digital fabrication technologies one day could be considered a traditional practice (Bottomley, 2004) with time what looks like disruptive technology becomes normal and vernacular.

Hereby, I present the process by which I became what I will call 'discipline-less' - yet, through this practice evolution – intrinsically better at teaching, making, designing and especially better at learning and sharing knowledge. By doing this research I have improved my critical analysis skills, and I have developed a tacit understanding of the processes of learning and logic reasoning, all of which proves hugely useful when teaching and tutoring.

6.1. FIRST PRINT, EVER.

My first 3D print was challenging and complicated, yet exciting and fulfilling. Previously I had had designs 3D-printed by a service provider, but had never printed anything myself. When I started the research I was sufficiently naïve to think there would be no gaps in that process. However, the act of printing did not prove to be straightforward – indeed, gaining access to a 3D printer I could borrow was a challenge. Not only was the technology-at-hand physically enclosed within a translucent box that, for the sake of safety, made it into a *black box*, but the printers were also situated in the Edinburgh College of Art workshop, to which access was limited and in high demand.

In organising a workshop, gaining access to this technology proved critical, yet challenging. A colleague suggested contacting the local Hacklab to gain access to a desktop 3D printer. After a few emails and some negotiation concerning access and printing materials, we got into the Hacklab on the 16/04/13, to experiment with a *Makerbot Cupcake.* The machine had been abandoned for a while, and no one was interested in using it or experimenting with it; indeed, it belonged to a former member who had since moved away. While the Hacklab members were accommodating in the setting and in providing technical advice, it was interesting to hear and perceive their responses to our curious inquiry. Although I had been in the Hacklab previously - to identify possible participants for this research study and enquire about membership - the use of 3D printing was treated with dissmissal. I found that members were no longer interested in experimenting, and their attitude indicated a perception that the technology was no longer challenging enough for their practice. On reflection, I surmised this may have been the result of its relatively recent mainstream uptake, and therefore its inability to fit within the 'bespoke' and 'craft' ethics of some of the participants (Levy, 1984).

6.2. FIRST WORKSHOP, PILOT STUDY

As shown in the previous chapter, the first workshop was deeply influential in my perception of practice and education within the context of emerging technologies. Through the full chapter, I analysed how participants perceived collaboration and how age difference was critical when approaching technologies. The perception of the difference between age groups and socioeconomic factors made me realise that claiming to run workshops in the name of democratising technology was still part of the dominant rhetoric among investigations into emerging digital fabrication tools, where researchers from institutions engage in co-creation workshops and case studies to assess the relevancy of technical issues (Wyatt, 2015). Additionally, I analysed how in a speculative (and often preferable*)* future, technologies redefine production and distribution channels as well as consumer habits. I agree in questioning the relationship between democracy and highly trained experts as Sally Wyatt proposes. As well as technology as a democratising agent there is much debate about this, and although it falls beyond the scope of this research project, such a line of inquiry is worthy of note.

6.3. THE FIRST TIME I BECAME A SERVICE; CHINESE WHISPERS[55]

This project was a collaboration between Chris Speed (ECA), Jane Macdonald (ECA), Diego Zamora (ECA) and Scott Baxter (Forrester High School, Edinburgh). This project culminated with an exhibition and workshop during the Edinburgh International Festival 2013. The project commenced on the 13th of August 2013 with the scanning of a sculpture maquette made by Eduardo Paolozzi from the Edinburgh University collections. Once the piece was scanned the file was processed using Blender, to fix missing dots in the digital mesh to ensure printability. It was then 3D printed using a *MakerBot Ultimaker 2.* The following morning the replica was taken to Forrester High School in Edinburgh to be modified by students by adding white plasticine. Students performed this additive activity during the first break of the day for ten minutes; then the transfigured model was returned to ECA where it was scanned, fixed and 3D printed again. This process was repeated 11 times, resulting in 11 heads. After

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[55] For an alternative account of this project and how it was treated within the Internet of Things you can go to http://chrisspeed.net/?p=1345

printing and modelling, the heads were exhibited in the Edinburgh College of Art sculpture court.

Figure 6-1-Paolozzi heads 1.

Figure 6-2-Paolozzi Heads, result.

This process was planned as follows;

Day planning of Chinese whispers.

9.00 Scott picks up object from ECA

10.30 Scott delivers the object to School for student 'hacking'

11.30 Scott delivers hacked object to Diego for scanning in Richard’s studio

11.30 Diego scans, and cleans up STL for printing

14.00 Printing begins

16.45 Printing stops.

However, the processes were not straightforward and reliable, and after five iterations the model started to transform dramatically. The modifications made by students became more exuberant, while the original form was both scaled down and smoothened by the digital processes. One of the first problems encountered was that the head was shrinking. Even though scanning and 3D printing were programmed to preserve the scale, the head was being consistently reduced, seemingly by no identifiable cause. Then the scanner was struggling with some of the features and misrepresenting them. Hence extensive repair work was required. There was an inflexion point when I had to change my approach towards editing the file and at some point, the geometry started deteriorating abruptly, so more hours were needed to fix it. Additionally, it started tilting to the point that it would not have been printable without a lot of support material. The ethos behind the project was to let the glitches of the process express themselves, however, letting it completely alter the shape would have misrepresented the activity of the students, hence losing the reference point of the head.

In this project, I was supposed to operate as a technician, by scanning, fixing and printing the model. It was never that easy, and the printing was never completed by 5pm. We all had unrealistic expectations. The project, whilst interesting, was a logistical challenge: 3D printing a piece of that size took around two and a half hours. What's more, the results of the scan varied each time, with day three, eight and nine proving particularly poor, and the fixing of the files was finished late in the evening, thus requiring overnight printing. After the fifth print, the 3D printer started having trouble with the filament, and at least three prints had to be repeated. This all had significant implications on my schedule, demonstrating that the technology required more attention and skills than anticipated.

6.4. DE-SKILLING MYSELF

As stated by participants and academic literature, one of the most common phenomena related to technological dissemination it is the capacity of displacing labour (Sparke, 2004). As exposed in this thesis, technology was perceived as driving 'professional meddling' by some participants. The image of the amateur, the DIY-er, and the designer-maker are contested within communities of practice, and the rhetoric of disruption caused by some technologies can create a perception of a daunting future. To further explore this, I decided to de-skill myself. Since part of the ideology of this research project is the dilution of power structures, I acquired a closer skillset to that of the participants. Albeit through experience and adaptability, I attempted to create cross-disciplinary workflows that were relevant within the practices of my collaborators. There are few projects that I developed on my own, but most of the creations are based on my sensibility and approach towards the systematic simplification of 3D modelling workflows. The main workflows developed through interaction with practitioners were;

-Picture to 3D model; capturing image, transforming it into vector file, importing to Tinkercad.

-Drawing to 3D model, very similar to previous process but with the added difficulty of needing to scan the drawing and then vectorising is more challenging.

-Material to 3D model, using 3D scanners physical models are transformed into 3D models, this often requires extensive detailed work on the 3D models.

As described in Chapter four, there was a process for selecting software to run workshops. Software was judged by its ease of application, the simplicity of its interface, the possibility of connecting pressure-sensitive devices and their capacity for exchanging files. This was crucial in the creation of a versatile workflow. However, in many of the cases, the limitations of these simplified tools posed unexpected challenges for collaborations.

Forensic Anthropology

As an example, the figure below presents the compression that TinkerCad performed on a file from a collaboration with the Forensic Anthropology department of Edinburgh University. It is interesting to note that the use of the technology within these collaborations differs from most cases presented elsewhere in this research. The forensic anthropologists were either looking for a way of representing specific features of Computer Tomography (CT) scans or traces of trauma left in bones of archaeological remains. Figure 5-3 presents an ancient burial that we wanted to reproduce. However, as shown in figure 5-3 the triangulation of the model using Tinkercad distorted the geometry to the point of making it unprintable. The skull, shown below, was used for a facial reconstruction, and as shown in the image the print had to be interrupted (or was interrupted accidentally) on several occasions. To demonstrate interruptions, I replaced the filament colour. Each cranium could take up to 16 hours to print. After a devastating fire in Glasgow School of Art, regulations at Edinburgh College of Art changed and we were no longer permitted to leave 3D printers unattended. Hence, printing something of this size was a challenge.

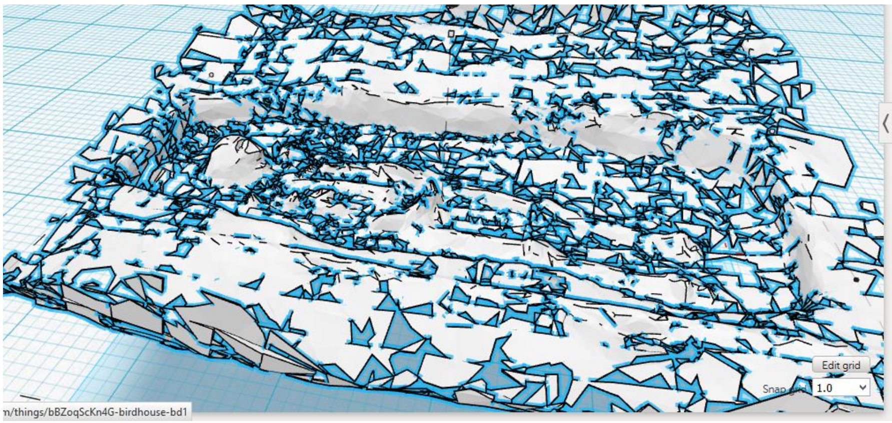


Figure 6-3-Burial model.

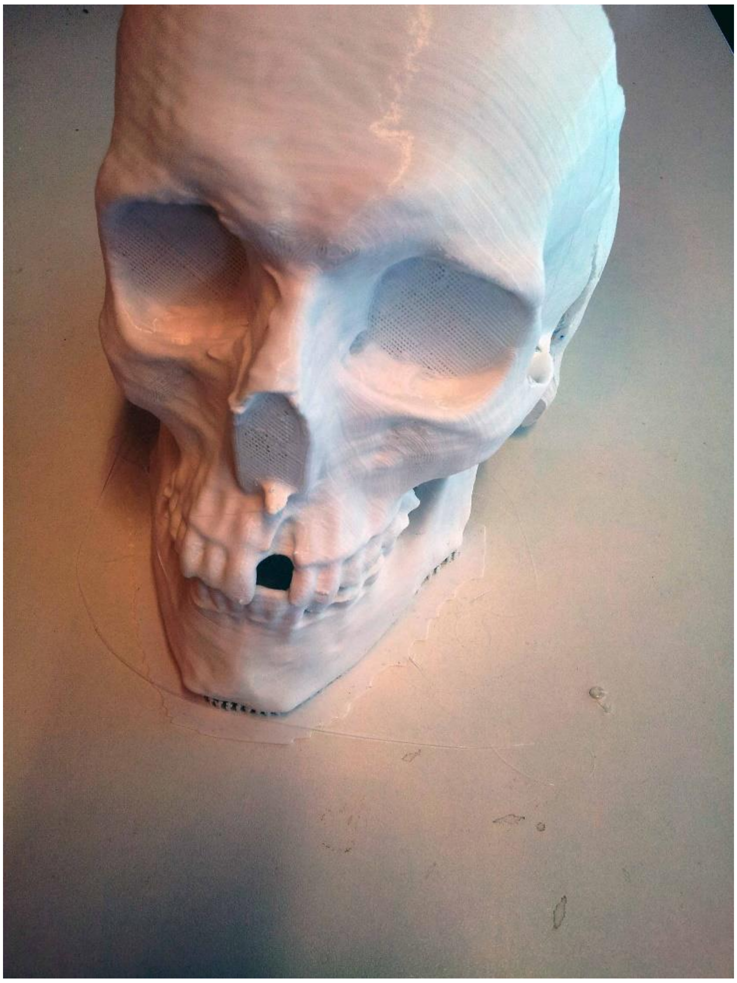


Figure 6-4-Skull for facial reconstruction.

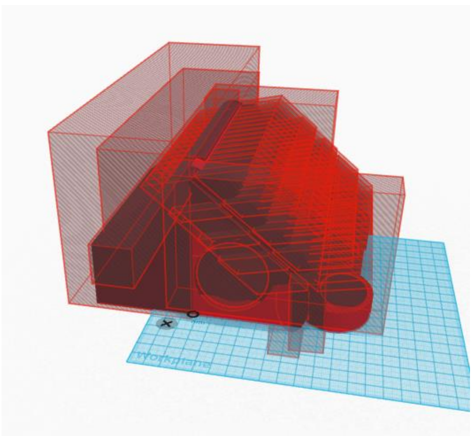
Birdhouse experiment: advanced design vs amateurish know-how

The aim of this experiment was to learn about Tinkercad and its possibilities as well as comparing how competitive someone using such software could be within the domain of design and engineering. The idea was to design a birdhouse with some containers for food and water using Tinkercad - an easy-to-use browser-based 3D design software. Then try to replicate the design using Autodesk's Inventor.

An array of technical difficulties was experienced when designing the birdhouse in TinkerCad. First – keeping the dimensions of the object to a certain scale: since TinkerCad can only handle dimensional edition from an orthogonal direction to the geometry, when the dimensions of an object are modified at an angle the geometry tends to be deformed without respecting the geometrical proportions. Additionally, there are no tools for creating patterns; this made the roof with the tiles very laborious. Furthermore, controlling the points of contact between geometries can be challenging, thus joining shapes can be imprecise and arduous.

To contrast with TinkerCad I executed the same design using Autodesk's Inventor. Although this resulted in a much faster process overall, there were limitations. For example, as an engineering and design tool, it took longer to generate food and water containers in Inventor than in TinkerCad, since copying a feature and modifying the dimensions is slightly more complex in this software.

The first image; Figure 6-5-Birdhouse experiment, Tinkercad file. Shows the number of operations required to create the roof with tiles in TinkerCad. Whereas, this was easily managed by creating a matrix pattern in Inventor, Figure 6-5.



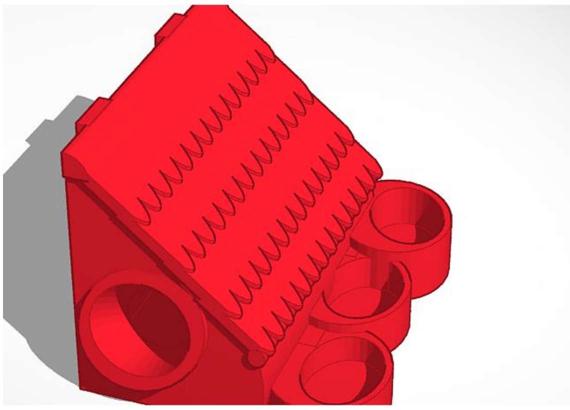


Figure 6-5-Birdhouse experiment, Tinkercad file.

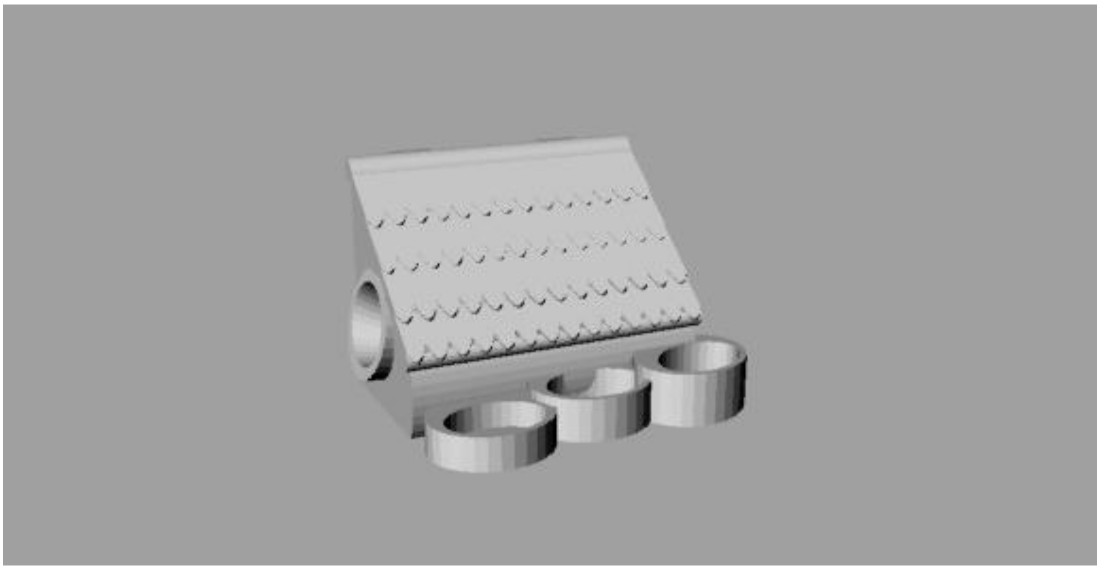


Figure 6-6-Birdhouse experiment, Inventor file.

6.5. THE SECOND TIME I BECAME A 3D PRINTER; OYSTER BOX.

In November 2013, I was approached by a graphic design student with the intention of creating a jewellery box, based on or inspired by an oyster. My first reaction was to laser scan the oyster to capture the geometry with the intention of further developing it.

The results of the laser scanning were highly detailed, and it immediately portrayed interesting qualities and glitches that could be exploited as part of the process. However, to make it into a box, something else had to be done. There were some constraints such as time and funding. As part of my experimentation with low-level processes, I decided to use TinkerCad for the development of this project. Although it was not going to be the simplest way around the design it offered an excellent opportunity to test the limitations of such a process. The first barrier encountered was the amount of detail that the model had. Tinkercad could not load the piece, so it had to be reduced by using Blender or scanned again with a dramatic reduction in the scan's quality.

Another challenge was to obtain advanced geometrical operations with primary tools as supported by Tinkercad, such as applying a fillet to vertices or smoothing out surfaces. These processes were done by subverting the tools that were already in place. Figure 5-6 shows the result of the digital files. This can be seen in the portfolio attached to this thesis.

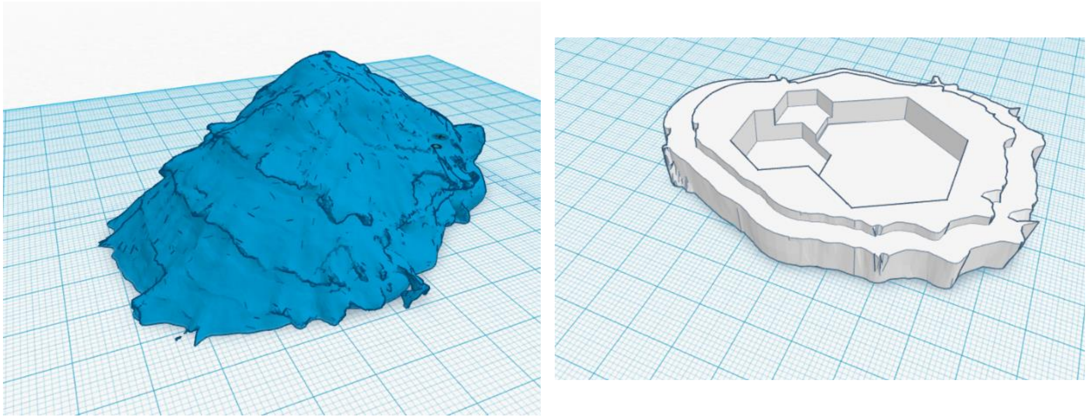


Figure 6-7-Digital models of the scanned oyster and the interior of the box.

6.6. SCANNING OF COMPLEX PENCIL AND INK DRAWINGS

After running a workshop, a participant approached me with the intention of making her drawings three-dimensional. Figure 5-8 below shows the complexity of these designs. These drawings were digitalised using a desktop scanner. The process of transforming this into a geometry was not obvious to me. I had previous experience of transforming simple lines and vectors into a model but nothing this complex. To represent the geometry and the many layers that line thickness portrays in a drawing was something that required further experimentation. My initial idea was to treat the full drawing as one and then modify it with Blender or Zbrush. To create the original geometry, I planned to transform the drawing into a simplified vector and then extrude it using Blender. Once the volume was created, I could start sculpting digitally. However, this would have been far too much input, and interpretation from my hand and was already moving away from the idea of using low-level 3D design methods.

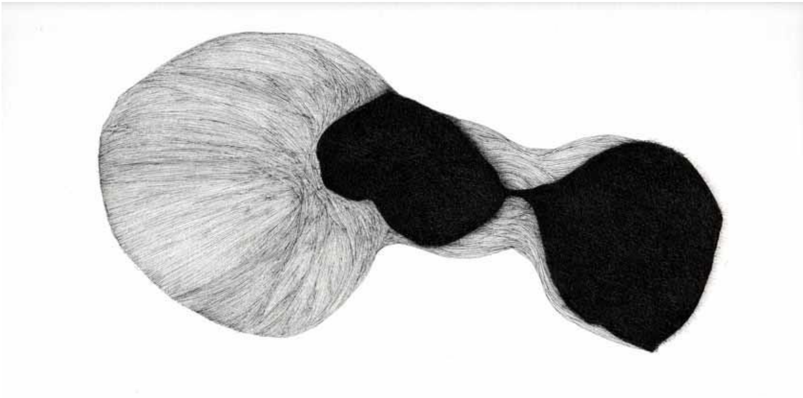


Figure 6-8-Drawing from participant.

The final process and the outcome Figure 6-9 and Figure 6-10 were deeply influenced by the software. For vectorising the drawings, I used Inkscape, the vectors were then separated into layers depending how salient they were on the drawings. They were then assembled using Tinkercad to generate the geometry displayed in below. Although this created an approximate geometry, by applying further editing using a more advanced program or importing it to Sculptris supported me in making it look more organic as per the drawings. The designs that were created in this way were never printed, as the level of detail dramatically increased printing times, and, as an example, the model shown below would have required six hours to print in an Ultimaker original.

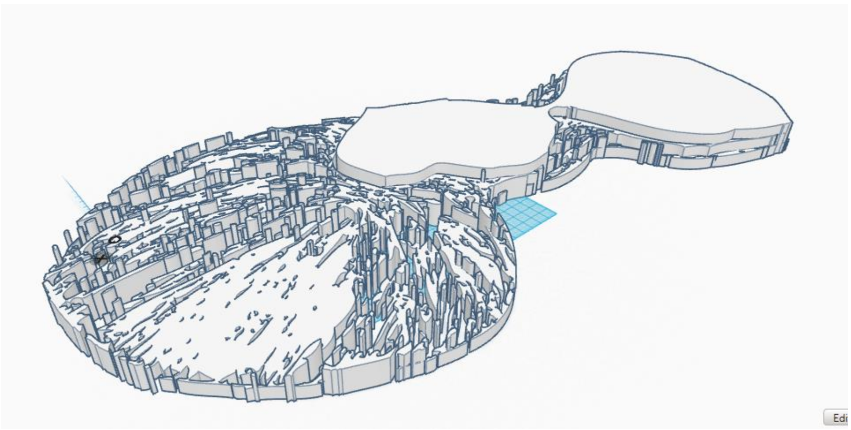


Figure 6-9-3D model of drawing.

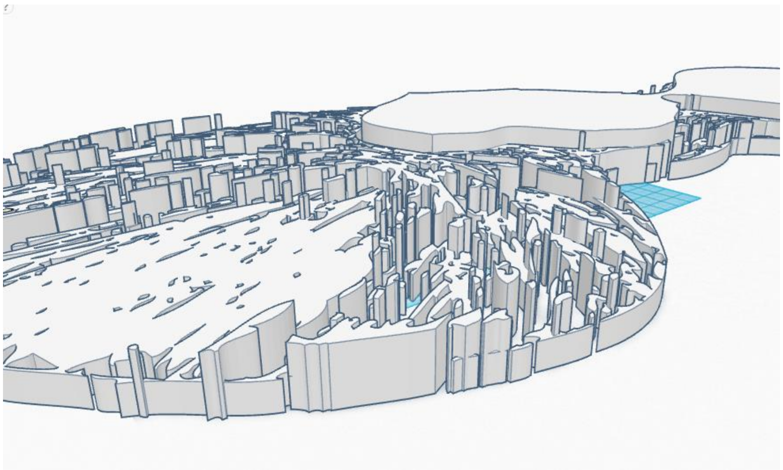


Figure 6-10-3D model of drawing, detail.

6.7. SCANNING TECHNIQUES

As part of a project for a workshop organised by Design in Action, I designed props for an interactive game for a workshop, that later led to the publication of a paper[56]. I also further explored the possibilities of designing geometries based on two-dimensional images. At the beginning of 2017, a feature was added to produce three dimensional QR codes in Tinkercad - however, at the beginning of 2013 this function did not yet exist, figure 6-11. The development of this, and its resemblance to an intricate structure of a city, triggered an idea to extract a plan from a .pdf and then adapt it to be 3D printed. This proved to be quick and intuitive once the process of extruding geometry based on a vector was established. The figure 6-10 shows the result of this, and to make it three dimensional I implemented a simple algorithm that generated ladders before adding some steps to the model, so it would more closely resemble the building. The following figure shows the final 3D print. The combination of these processes and experimentation with very basic architectural concepts offered the perfect opportunity for developing *Nottobereproduced* when the opportunity arose.

[56] https://dl.acm.org/citation.cfm?id=2757234

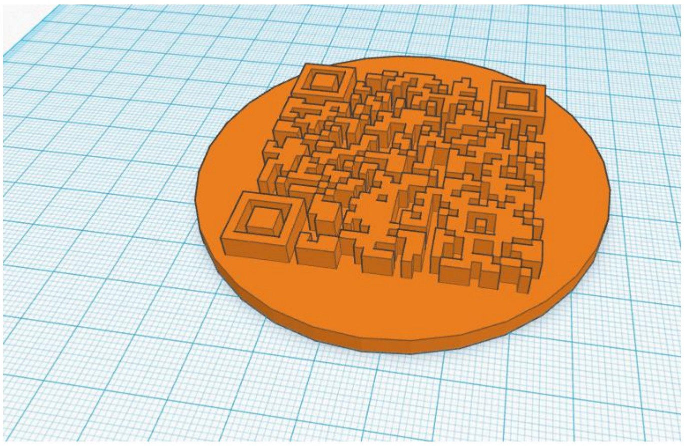


Figure 6-11-3Dimensional QR code.

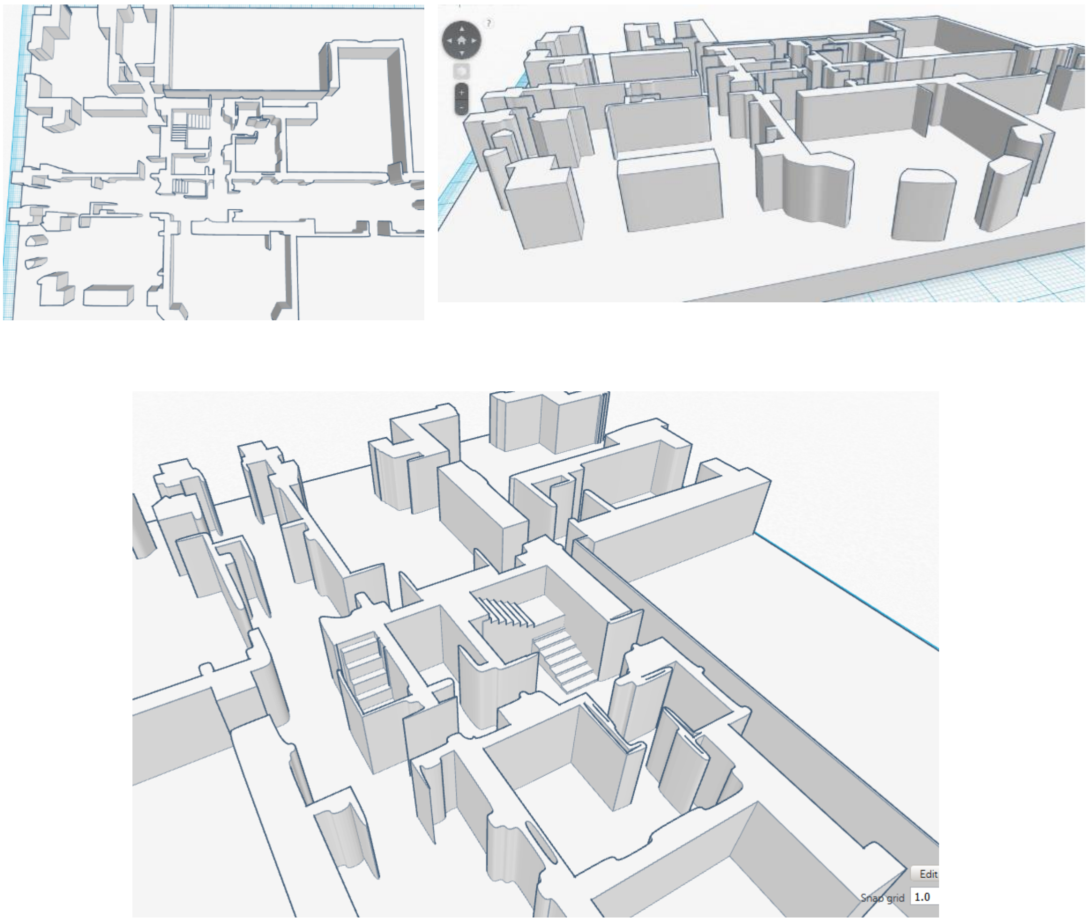
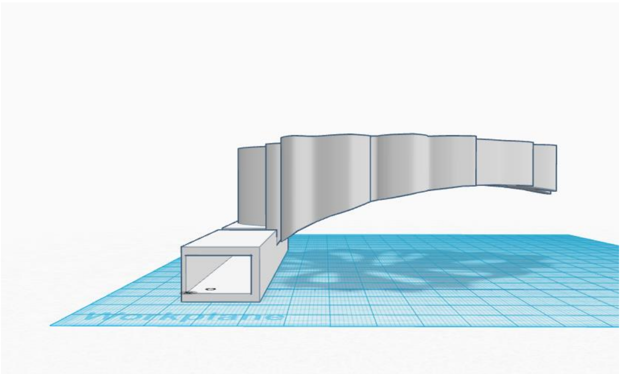


Figure 6-12-Architectural model extracted from pdf of a plant view.

6.8. LOW-LEVEL DESIGN PROTOTYPING

After dwelling on this approach for some time, the opportunity to test it with a real design brief presented itself - a designer approached me with the intention of creating a wind shield in the form of ear protection that could be attached to the strap of a cycling helmet. Since it was an early prototype, I decided to use one of the geometries I already had created and try to adapt it to the specifications of this project.

The first approach was to carve out the leaf and give it form by combining simple geometry and using Boolean operations to shape it. Shown in figure 6-13.



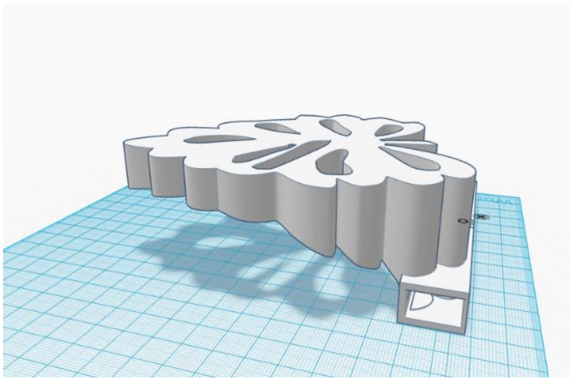


Figure 6-13-First prototype for ear protection.

After initial testing, it was discovered that attaching the leaf to the strap was harder if it was a closed geometry, so changes were made to be able to clip it on the straps of the helmet. Additionally, the design looked cumbersome and felt sharp. Hence, I adapted the same object using Sculptris and made the form more organic and lighter, thus leading to the result shown below. Prototyping stopped at this point; yet, although it is an incomplete design case study, it helped me to assess the ability to face real challenges to design and making when using amateur or entry-level 3D design tools.

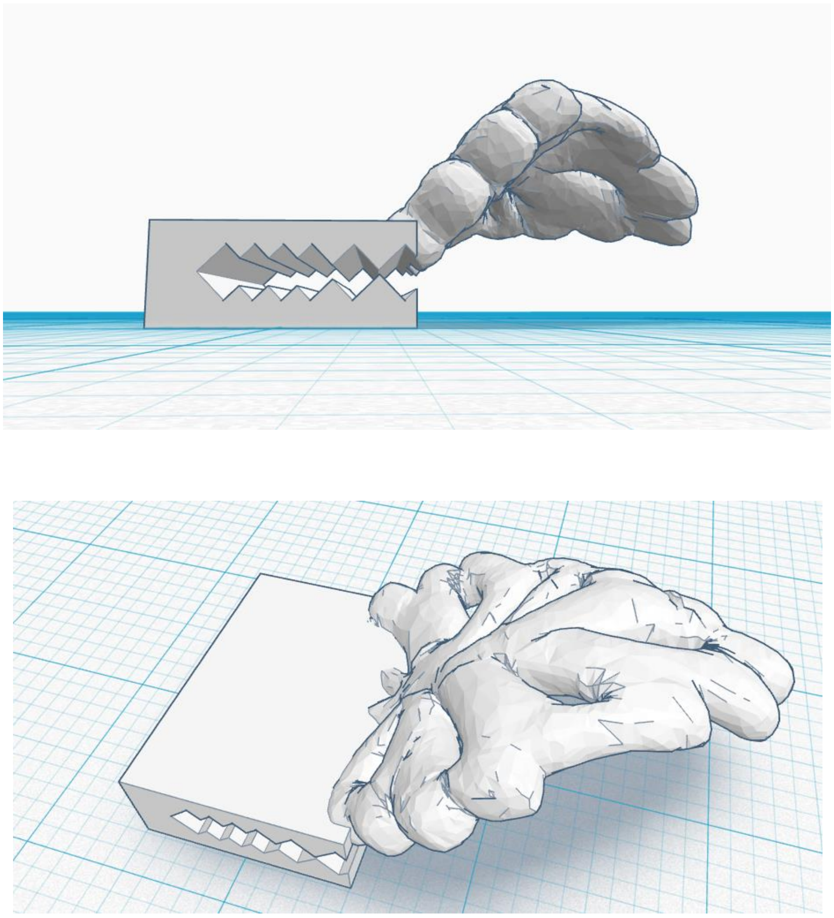


Figure 6-14-Second prototype for ear protection.

The design process was fluid. However, there were some limitations that did not allow the matching of the organic shape with the geometrical shape created for the clip. At the time, I could not find a free-to-use software package that could support the collation of both organic shape design and geometrical design.

6.9. OTHER EXPERIMENTS AND APPROPRIATIONS

As shown above, in the layout of an ear protection, there was a need to redefine the way the different software packages were used. As a designer, I wanted to find a way in which creations would not be either geometrical or organic. When designing with Sculptris, one always begins with a ball, which makes it challenging for creating certain shapes.

When defining creative workflows to approach 3D printing, it became critical to be able to combine the geometrical tools with the organic creating tools. Hence, there was a need to explore the possibilities of connecting Tinkercad with Sculptris. Although it is not a straightforward process, it is relatively easy to generate an extrusion based on a vector file in Tinkercad and then export it into Sculptris or Blender where it can be modelled using the hand-based design tools.

Figure 6-15-Vector file to Tinkercad to Sculptris.

For that to happen, any image can be vectorised using Inkscape or Illustrator and then exported to TinkerCad where a volume can be easily produced. After this, it needs to be exported as a .OBJ file and imported into Sculptris, where it can be modeled freely.

The use of images to vectorise into vector files allows for a range of creative activities and appropriations, as the *stolen* RBS logo I created and 3D printed for an RBS talk.

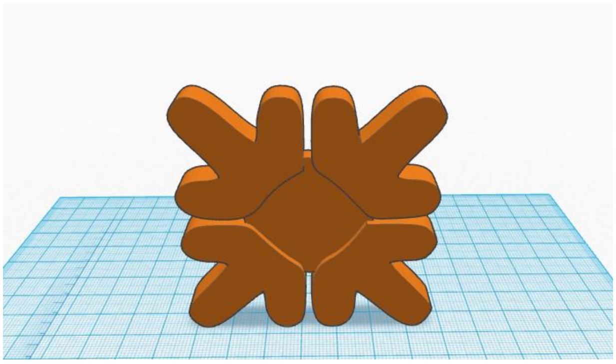


Figure 6-16-Appropriated RBS logo.

6.10. ADORNED AFTERLIFE PROJECT

This project was based on the relation of mortuary industries in Egypt around 1900 B.C. with artefacts destined to accompany the dead in the afterlife. The Reid mummy was a central piece in the ideation of this project, and we were given the unique opportunity to work with a Computer Tomography scan (CT) of the jewellery that had been laid with the mummy to accompany and guide the dead in the afterlife. These pieces had never been exposed, as the wrappings of the mummy are preserved intact. To explore the mummy and the elements it was buried with, the remains were scanned and assessed by Forensic Anthropologists. Hence, the objects had only been explored digitally. The handling of the digital files and the idea of appropriating the techniques and narrative of creating jewellery for the afterlife were the starting point for the development of this project.

Adorned Afterlife aimed at developing connections among researchers from various disciplines, including material research, archaeology, jewellery, and Egyptology, with jewellery designers and makers. The project was backed by the National Museum of Scotland and the jewellery department of Edinburgh College of Art, among other educational and research institutions.

I participated in this project as a research assistant and supported the application for funding from AHRC: Digital Transformations. The original idea was to further explore the possibilities of contemporary making and approaches towards Egyptian mortuary industries. Although the application for the grant was unsuccessful, we managed to secure funding in the form of a networking grant[57]. This helped to develop a network of people with close ties to material practices.

Part of my activity was the development and exploration of the possibilities that having access to a high-level 3D scan of an ancient piece of jewellery could give us as a network. Using the files for replication and appropriation of ancient sacred works of art and transforming them into contemporary digital transpositions of the afterlife. As a group of researchers and practitioners we wanted to create a link beyond materiality with ancient ways of making that assisted the human soul in the transposition to the ephemeral. Using 3D printing and digitalisation processes seemed adequate to do this. It could be argued that the digital will withstand our lifetime, hence the digitalisation of material culture could be regarded as a mortuary process, one by which we preserve and are accompanied in our digital sepulchre. With this idea in mind, I worked with the figure of the scarab that was embossed in the metal plate on the forehead of the mummy to transform it into a digital

[57] http://www.adornedafterlife.eca.ed.ac.uk/

legacy. Thus, I created a necklace and a plate to be stitched over a textile adornment. Both were presented as part of the exhibition during the symposium.

As shown in the figures that follow, I used TinkerCad as much as possible, however, for the fixing and edition of the three-dimensional meshes I used Blender since it offers a point by point tool set. It is noted that the model could have been resolved to a higher degree of smoothness, however, it achieved the goal intended as being printable and of sufficient quality to use it for other creative activities.

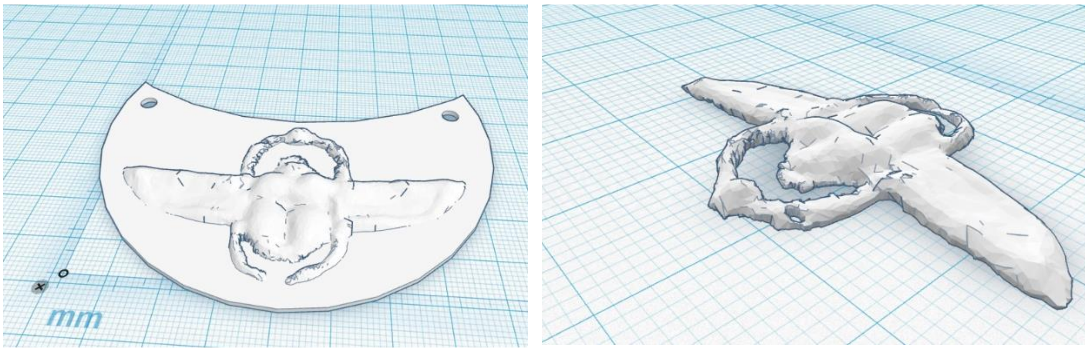


Figure 6-17-Egyptian beetle.

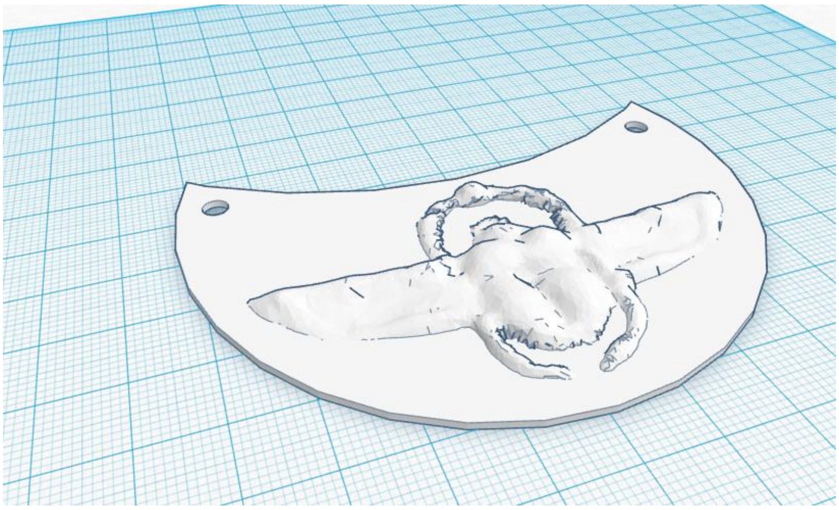


Figure 6-18-Egyptian beetle on garment.

6.11. SUMMARY/CONCLUSIONS

The tone of this reflective chapter is different from the rest of the thesis, it comes out as an approximation to the development of my practice and is linked to the portfolio presented with it. This report was considered since in the rest of the thesis it is not reflected how I transitioned from a perspective of fascination in and devotion to the dissemination of 3D printing, to one of disbelief and scepticism. Perhaps the criticism that is expected of a doctoral researcher grew in me. Indeed, perhaps it was the realisation that technology, after all, is an object of consumption. Thus the same tactics – of marketing, trends, programmed obsolescence and advertising, moreover, psychological factors of consumer culture - seem to operate within the sociological definition of technology, where self-inscription, personal identity, and difference are among the principal motivations for consumption (Hackett et al., 2008, p. 5)

In this chapter I have reviewed the inspirations and limitations of the processes of the creative experiments and outlined how they were presented in case studies and to practitioners through workshops. These processes clarify the need to find a contextual toolset for use in approaching new tools. As seen in the previous chapters, this is a critical part of the adoption of new techniques or processes within creative practices; worthy of note is that some practitioners voiced their concerns in supporting this. Thus, it seems that if a practitioner cannot connect with the supporting technologies of an *emerging* technology (such as 3D modelling and editing, or 3D scanning in this case), then the transfer of skills proves a greater challenge. It can be likened to attempting to use the internet without prior knowledge of how to use a computer or web browser.

By introducing this review of my personal and critical development, I hope to have demonstrated the way in which my practice as a designer, an engineer, and a teacher has evolved. Getting closer to my participants was not an easy task at times, however, it significantly enhanced the learning opportunities of both parties and certainly offered insights within the context of 3D printing and craft.

7. DISCUSSION

Through this thesis, I have examined the use of 3D printing within the creative collaboration. This line of inquiry evolved from the onset of what has been touted as the '3D printing revolution' toward a more critical position in which the role of a 3D printer was understood as an instrument within research through design. I have provided evidence of engagement with creative practitioners from a wide range of disciplines and ages and evidenced the development of practical and educational skills within myself and collaborators. This sharing and developing of skills provided opportunities for experimentation with others, achieved through workshops and individual collaborations. The use of contextual literature within this thesis allowed for the development of an analytical framework based on existing technological dissemination theories and creative practice. In this chapter, I discuss relevant issues supporting the main arguments for technology-mediated craft collaboration as a catalyst for critical technological engagement. This section will identify four primary insights for the community; Professional Meddling, Displacement of labour, on physicality of practice and Bending technology as a framework for collaboration.

Emergent themes from Factor Analysis

Factor Analysis (FA) is one of the methods used in this thesis for analysing data, as described in the Section 4.4, these statements can be taken as hidden dimensions within the data set. However, they rely in the interpretation of the analyst and can be difficult to come to the coherent interpretation of the results (Yong and Pearce, 2013). In this case, the FA results were used as guidance for analysing discussions and qualitative data. At this moment, I present disclosure of themes emerged from the FA and how they relate to the rest of the data.

Per the Table 4-8, page 113, most relevant factors are:

- Factor 1: New practices emerge within technology but can not be considered hand-based practices.
- Factor 2: Increased confidence in individual creative experimentation with 3D printers.
- Factor 3: 3D printing will be a positive addition to a creative process.
- Factor 4: Lack the opportunity to 3D print. Have the skills to model but remain uncertain about 3D printing.

- Factor 5: I am willing to experiment, lack knowledge about design and 3D printing.
- Factor 6: Handmade objects are emotionally more valuable than machine-made.

Factors 1, 3 and six are related to the role of 3D printers within established practices which has been covered at length in the qualitative analysis section, page 113. Additionally, they are covered in this discussion in section 7.2. Factors 2 and 5 are related to the impact of the workshops are discussed in section 4.4. Factor 4 is related to access, and it was debated in the focus groups and case studies, it is again discussed in section 7.2.

7.1. DE-MATERIALISING PRACTICE

Central to this research is my development as a lecturer, facilitator and designer. However, I consider that my practice has evolved in a somewhat peculiar manner. As a technologist, but not necessarily as an advocate of 'technologising' creative practices -or "digitalising" practices as Adamson puts it (Adamson, 2007a), I have identified myself within a 'user-centred diffusion' of innovation theories (Eugene Pereira, 2002). The role I played, as per many other designers, makers and educators, can be identified within the spectrum of early adopters and innovators. However, in conducting a literature review on the diffusion of innovation theories, I discovered a role that is often misrepresented - that of the 'technology-enabler'. While Rogers' theory is based on time, and Pereira's on adopter personalities, the role of social factors and collaborations is underplayed, as suggested by peer-to-peer manufacture theories. Von Hippel defends that there is a group of practitioners that enhance technological diffusion by actively engaging with groups of technological production and manufacture (Von Hippel, 2005).

The role of the technologist-practitioner educator is still not well represented within this context but could be, as such: practitioners that, as a role model, offer exemplary practices and, at the same time, develop methods and approaches towards emerging technologies that concurrently generate more significant opportunities for others. As for example Risner identifies:

> *"However, for most participants access to equipment was only possible in the company, and under the direct control, of a skilled operator (usually their project mentor) who had extensive experience and carried out machining tasks alongside the maker, taking on board decisions and possibilities suggested as work was undertaken. Mentors, for example, took a substantial role in preparing files for machining. The question of*

> *access to digital equipment is therefore bound up with the question of access to the skills needed to operate it."(Risner, 2013, p. 177)*

Lead users and innovators as defined by Eugene Pereira, 2002, Rogers, 2010 and Von Hippel, 2005, play a crucial role in the social acceptance of the technology, but within this domain, the role of educational practices seems to be diminished. As we have discussed earlier, hacker ethics and collaborations are similar to the interactions between this type of practitioners (Jordan, 2008; Levy et al., 2003) yet the dynamic works as it's among equals. Within Science, Technology and Society (STS) scholarship there are alternative definitions that seem to offer a better fit, such as the "warm expert"(Bakardjieva and Smith, 2001) or "local expert"(Stewart, 2007). Although these definitions offer a better understanding of situated social practice within emerging technologies, they are still far from the role model of practitioners-lead users, that we have seen through this thesis. Jane Taylor and Katherine Townsend suggest the idea of the "technician-designer" as a way of representing how contemporary makers need to develop an intimate relationship with digital fabrication technologies to reach a higher level of expression and creative freedom. From my point of view, this "technical-designer" represents what I had to become to develop this research. However, it does not give a full representation of what I -among others- have been doing for/with creative communities. If we look at the same case that Townsend uses; Drummond Masterton, we can appreciate the quality of his work and the outcome of what developing a relation to digital fabrication can produce. Under the same scope, I am particularly interested in the work of Anders Kruse Aagaard[58], from Aarhus Arkitekskolen. Through innovative use of a six-axis CNC milling machine and extensive modification, he can create complex, flexible wood forms. His work demonstrates the experimental exploration of digital fabrication, but as a side effect, he had to expend days and nights working with the machine to the point of becoming one of the inhouse technicians.

[58] http://aarch.dk/person/6819940cabfa6840978e71a253eed32f/#/publikationer

Figure 7-1-Anders Kruse Aagaard woodwork.

I argue that this relation with the technology and the ones who have some experimental curiosity goes beyond a technician-student or a peer-to-peer dynamic. Wenger et al. Introduce the notion of the "technological steward" (Wenger et al., 2010), offering a role model within sociology of technology that seems to adapt better. The "technology steward" offers technological expertise to a community, as the other models offer, but in this case the needs of the community are at the core of the interaction. However, stewardship downplays the role of collaboration. Hence, I propose a collaborative approach towards emerging technologies that take on *bending technology* as the departing point.

Throughout this research, I remained active within a community of practitioners involved in digital fabrication. At the same time, to reach out to more participants and to be able to provide a consistent learning experience I have had to simplify my approach towards digital workflows. This situation required me to move away from my engineering background. On a personal level, this provoked a profound change in my perception of design practice. One of the side-effects of this is that I now no longer produce prototypes made of wood or other materials - my practice as a designer has become mainly digital and conceptual. My skill set now relies on easy to use and open source tools, to some extent what was my professional practice had become an amateur set of skills and workflows. On a professional level, I feel closer to those who were willing to work with me and explore the technology. As Beegan and Atkinson suggest my role as an expert that uses an advanced set of tools and skills did not seem as relevant as my role within the community and willingness to share and develop with others; getting closer to vernacular design (Beegan and Atkinson, 2008) and potentially de-professionalising my practice.

7.2. IDENTIFYING BARRIERS TO EXPERIMENTATION

> *"Those cultural practices that do not engage with Modernity, which will speed and grow exponentially from now on, will be peripheral." (Greenhalgh, 2002, p. 207)*

Using surveys, I gathered data about the perceptions of 3D printing and the role of digital fabrication technology within creative practices. Using focus groups and collaborations, I further explored these issues through statistical analysis. In this chapter, I collate and expose the most striking and conflicting views from the three modes of engagement.

Confronting narratives of disruption

Emerging technology - especially when supported by narratives of disruption - fosters the development of anxiety and fear among some creative practitioners whose field might be arguably affected by the new technology. It is widely accepted that older generations struggle more when adapting to new technologies (Aagard, 2006; Loges and Jung, 2001; Newman and Hatton-Yeo, 2008). However, it is unclear, given the exploratory and experimental identity of craft, if this applies to the arts and crafts creative industries, according to the Scottish executive and the Crafts council adoption of ICTs among creative practitioners remains low (Burns et al., 2012; Ferraro et al., 2011). There is a lack of human-centric technological studies among STS studies; this is represented by the attempt to identify individual strategies for overcoming technological anxiety. In her seminal work, Sally Wyatt explores the limitations of STS studies, by offering a comparison of analytical methods and suggests that there is a need for more community and human-centric methods for analysing technological dissemination (Wyatt et al., 2008). Even further, she suggests that technology is often evaluated from an individual and emotional point of view that is often misrepresented in the literature and research (Wyatt, 1999)

As we have seen in the workshops chapter, practitioners - and especially those who were older - were more impressed upon by the rhetoric of disruption about 3D printing coming from mass media sources. This resulted in unrealistic expectations towards the technology and generated certain anxiety:

> *"I felt really nervous before coming here, 3D printing was scary and did not know who was going to be here." L, Ceramist, 60 Y.O. OLEUS workshop.*

> *"I felt the same, I was quite open minded to give it a try; now I find it fascinating, and somehow enjoyable." JE, Stonemason, 50 Y.O. OLEUS workshop.*

This was further explored in the interviews and within the longitudinal collaborations. Trying to approach the issue from a different perspective. I interviewed Jennifer Gray, a self-defined designer-maker;

> *"I have friends in the industry who are in their 60s; they are not going to learn it [Digital fabrication]. So, there will be companies that overtake them, as they can produce faster. If it is a small company, it could pose a challenge for them, but bigger companies have already embraced it, like casting companies and jewellery - they all embrace the digital stuff. I guess like photographers had to embrace digital." JG, designer/maker, 30 Y.O., female.*

As noted by participants, and observed in the analysis of quantitative data, it was clear how mass media had contributed to the development of unrealistic expectations, as Gell argues mass media is part of the 'technology of enchantment' which contributes to the creation of an idealised pattern of behaviour (Gell, 1999) I argue that this *enchantment* is at the core of the fear that participants experienced prior to taking part in the workshops. This perception of risk, associated with the development of technologies, is strongly linked with the idea that digital fabrication could displace the role of those whose practice is strongly dependent on traditional notions of non-technological labour. Through this research the underlying factors of this perception were identified as:

- fear of being left out by the displacement of labour and emerging skill sets

- the notion that technology fosters 'professional meddling'; technology enables professional permeability.

- loss of the relationship with materials and kinetic experience as a form of self-expression.

Quantitative data supports the notion that direct material manipulation is at the core of craft's exploratory nature. I further explore this question later in this chapter.

The risk perceived by modernisation as defined by Beck is related to technological advances and structural changes (Beck, 1992). These technological pulses influence society to place trust in expert systems (Giddens, 1991). When we perceive a potentially disruptive technology, the trust and confidence in those expert systems falter. Hence the need for a personal strategy to confront change. As defined by Rodgers and others (Coyne, 2007; Moore, 2002; Rogers, 2010; Schumpeter, 1942) there is a range of positions that can be assumed within technological societies that provide individuals and groups with a 'role' to play when these potentially disruptive narratives are introduced. As introduced in the literature review, within technology dissemination studies it is common to find definitions of role models who believe technology represents progress, hence embracing a techno-deterministic and overly simplistic approach towards studying technology (Sporton, 2015) During this research participants expressed perceptions that aligned with this, as well as contrasting views:

> *"I mean I didn't want to contradict anything that's been said. However, I think there's also a common sense that technology is progressive: it stands for progress and yet there is a hyperbolic view of technology. I think a lot culturally. But by the same token, I think people have talked about technology regarding remediation: that they remediate what is already there. We tend to think of technology, the way it is presented in mass media, is new." GL, craft practitioner/lecturer, 50 Y.O.*

The participants of this research perceived 3D printing as an opportunity, yet, as a potential disruptor in some creative practices, specifically in small craft studio practices. The unique challenge that 3D printers were believed to introduce was the possibility of digitising and materialising arts and crafts objects, thus potentially bringing the economic dynamics that shattered the long-standing music and print media industries when they moved into digital distribution, i.e. Napster, desktop publishing (Desai and Magliocca, 2014). The seasoned craft practitioners approached as part of this research, were afraid that 3D printing could profoundly influence distribution and value chains in their field, hence distorting their economic stability.

It is important to note that there was a marked divide among participants. Besides issues related to digital migration, where age is determinant of the use and technical ability with digital tools (Prensky, 2009). There were two well-differentiated groups, those who were enchanted by mass media rhetoric and believed 3D printing was going to be ubiquitous and industry changing, potentially threatening craft production (defined in Figure 7-2, below, as optimistic/hyped). Moreover, a second group who did not perceive much risk coming from the technology and sought to shatter media paradigms (defined in the figure below as realistic/critical).

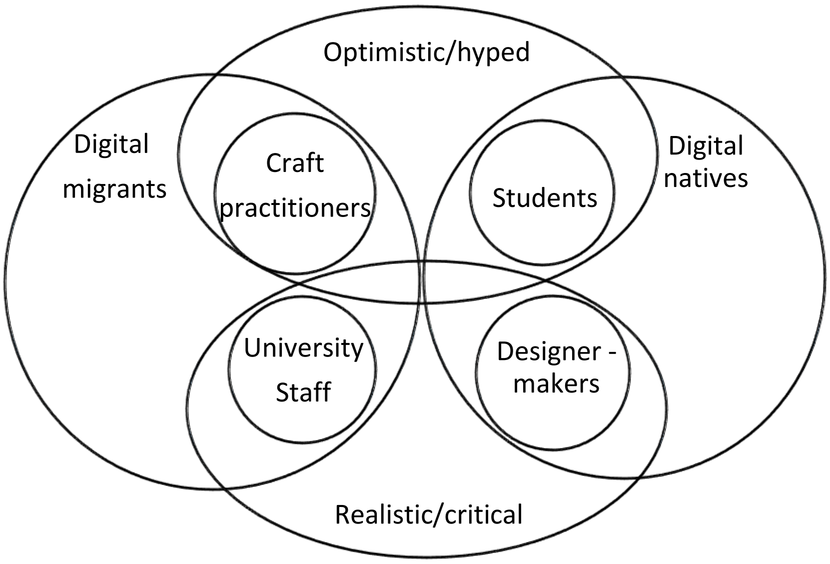


Figure 7-2-Relation of occupation to perception of technology by age.

However, some of the participants identified possible ways of finding new forms of distribution and publication, such as making small series of objects that could be distributed and sold at a low price as online merchandise (see OLEUS transcript in Appendix B). Additionally, an emerging aesthetic was identified as well as potential ways of developing compelling narratives within the digital workflows related to 3D printing. The figure below shows the sketches made by a participant trying to explain how he would appropriate the aesthetic of the support material to create a stone setting for a piece of jewellery.

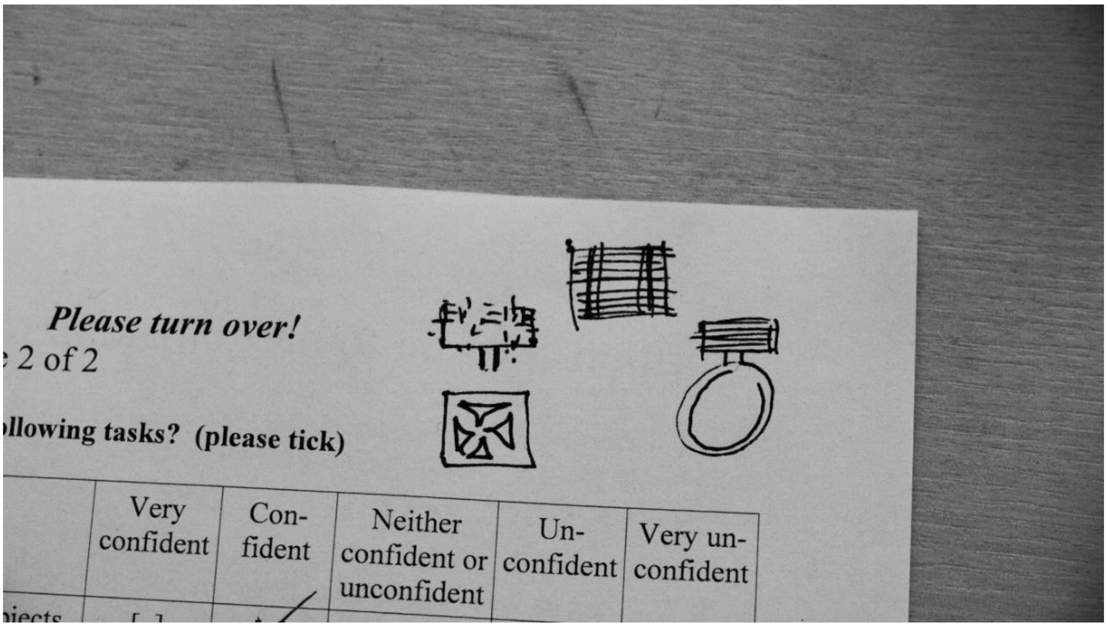


Figure 7-3-A "natural stone setting", appropriation of the aesthetics of 3D printing by-products.

The notion of evolutive technology was identified as an anchoring technique for some of the participants. This was a way of being able to transfer from one iteration of a technology to the next, even though if they voiced that *"We all have software I think we don't upgrade"* workshop D, it was noted that *"the best people working digitally are those who are the best working with analogue"* workshop J. Thus, providing an example of how technological flows don't challenge the sensibility and knowledge that makes a practitioner stand out. In his paper, *Can computing be a craft?* Jeremy Myerson, paraphrasing Guy Dyas, defends that "*using the computer is not a craft in itself; it is utilisation of a tool, no matter how creative the outcome; the real skill in utilising that tool is derived from traditional design knowledge*"(Myerson, 1997). This, I believe can give practitioners a reassuring point of view when considering emerging technologies.

However, this is profoundly influenced by a Darwinian perception of technological evolution. To propose an alternative view, I want to draw on an alternative account of evolution, Bergson's *Creative Evolution*. Bergson defends that evolutionary processes -as we perceive them- are marked by changes within complex systems, but that sometimes, given our perception of time we struggle to identify the real subtlety of the changes within the entity under study by just perceiving a change in state or form (Bergson, 1998). The definition of materialism given by Latour through a "thin description" (Latour, 2007) offers an exemplary way of understanding how through failing to understand the complexity of the technology and the underlying principles of its evolution causes a feeling of disconnection and in some cases fear. I argue that these are the factors that contribute to the creation of what we have identified as 'black boxes'.

Professional meddling

Participants, usually mature craft practitioners, discussed technology-enabled professional mobility during the focus groups, as well as, during debates that emerged during other creative activities. For most of the craft practitioners that participated in these debates, technology was perceived as an enabler of cross professional and trade permeability that often challenged their economic environment. I defined this as 'professional meddling', that is the ability of contemporary practitioners to go beyond established definitions of discipline and practice. According to participants, the role of the amateur[59] was defined as instrumental in this process and associated with the production of lower level yet competitive objects. Contrary to this, as shown in the data, younger practitioners would self-identify as practitioners who were "beyond discipline":

> *"I suppose I am feeling multi-disciplined, and what I make crosses a few disciplines…I have an interest in design and…I was doing jewellery, but it could have been another subject. However, I loved the small sculptural form you could make, so it made sense to do that. I learned to [gather] and to be challenged, so I do like to have a commercial outlet for it, not just making for myself. You know - littering the world with things which aren't used. So, I would sometimes do either the most functional things, they are fairly elaborate, or they are luxury goods I suppose. However, at least they have an application or a purpose." Jennifer Gray, designer/maker, 30 y.o.*

For younger participants of this research, technology only enabled certain types of creations that were different from everything all together. Thus, avoiding the conflict of perceived professional meddling.

> *"The technology means that people [that] are architects... If you know how to use Rhino, they can create objects and jewellery objects. It could be anything really, so they do not need to have the traditional background of metal working but then they are different objects [referring to digital fabrication as compared to handcrafted], and it is cool as well, I mean I*

[59] Participants referred to amateurs as unskilled practitioners.

have done it as well, and some of the works are great. However, then, there are more designers in a way." Jennifer Gray, designer/maker, 30 y.o.

Under this light, I decided to study firstly what caused such a perception. Secondly, what were the barriers that were in place to provide opportunities for practitioners to explore these technologies through 'professional meddling'. Thus, I identified a strategy for approaching emerging technology in which craft practitioners are well-versed; collaboration. Drawing on traditional ways of transferring knowledge within master-apprentice dynamics, I set about exploring contemporary modes of engagement and education within creative education institutions with a focus on emerging technologies, namely 3D printing.

This study focused on independent creative industry practitioners, as well as those with relation to academic institutions, and at different levels of their professional careers. Mainly, students from Higher Education Institutions, principally Edinburgh College of Art, as well as creative communities of craft practitioners in Edinburgh and developing artists living in Scotland.

During the process of identifying barriers through workshops, debates and interviews, several issues promptly arose. These included: the cultural values of most of the craft practitioners who participated in the study were antagonistic of technological development and an increasingly digitalised workflow. The direct relation with physical manipulation, the kinetic relation with the manufacture and the sensory experience of creating with the hands and essential tools hamper the experience of experimenting with digital tools, thus resulted in a feeling for the practitioner of being removed from the process. Beyond these seemingly self-imposed barriers, many others emerged during the focus groups. Some of the most critical barriers were:

- Access to technology and skills
- limitations in expression
- ownership of the underlying processes
- oversimplification of processes
- the distance between creation and production
- distortion of manufacturing narrative
- a barrier to communication
- usability of new technologies.

It is important to note that these barriers have been identified by other researchers in the field, as for instance access to technology and skills and ownership of processes have been covered by Risner, 2013. Based on the conclusions that she draws from her research she proposes a possible line of enquiry that I have developed further:

> *"Convergence of tools may deliver shared working practices, and the democratisation of tools may deliver ease of use and possible crossdisciplinary working, but may also undermine the professional standing of highly skilled craftspeople by diluting practice."(Risner, 2013, p. 254)*

Tellingly, during the workshops, older participants (those between 35 and 60) voiced their concerns with learning new digital skills whereas younger participants were very enthusiastic. At the same time, the data suggested there was more confidence in collaboration, challenging and exposing their practice among older practitioners. This set the tone for the development of longitudinal collaborations with a range of practitioners from many disciplines, mostly associated with craft processes, and varying ages. At this stage, I assumed the role of a technology facilitator while trying not to *own* the technology, so to give as much space for exploration and development with 3D printing as possible. These longitudinal collaborations offered an opportunity for challenging the propositions and ideas brought up by workshop participants, as well as exploring the role of collaboration for the diminishing of technological barriers within a creative context.

The notion of 'professional meddling' as an issue when considering emerging technologies has evolved through this research. Initially, it was linked to professional intruders as it was voiced by craft practitioners when discussing the role of amateurs using Etsy to sell craft articles. However, that view seems to undermine the role of amateurs who are often at the front of innovation, not only in technologies but arguably, in most disciplines. Sporton defends that the origin of modern science is related to amateurism, mainly driven by curiosity, often far from financial gains and expectations (Sporton, 2015, p. 25). Furthermore, Beegan and Atkinson defend that amateurs are often bolder and more experimental than professionals within a field (Beegan and Atkinson, 2008). I defend that the role of an intruder would by far fall sort of defining the contributions that a committed group of individuals could bring to a profession. However, it is necessary to acknowledge specific professional mobility often facilitated by emerging technologies.

On physicality of practice

In the longitudinal collaboration NOTTOBEREPRODUCED, I explored the possibilities of getting physically involved in the operation of the machine differently, while the production of textiles for WEAR3D operated and appropriated the process of 3D printing. The creation of the half-finished prints for NOTTOBEREPRODUCED required constant interruption and action to create the desired effects. Such use of a tool cannot be considered automatic or dissociated from the material. Although the PLA (the plastic used for printing) was never touched, there was a high level of physical effort involved nonetheless - stopping the machine, displacing the printer head, removing the filament and placing a new one when repeated every other minute – this proved highly demanding. David Pye defines the “workmanship of risk” as the true characteristic of craft. By committing to risk, the ability to manipulate a material through a sensual relation (Adamson, 2013) the practitioner exploits the opportunity for self-expression. For me, navigating the opportunities of this process felt more akin to spinning wood on a lathe. When the tool cuts, extrudes with timing and intention and produces the desired result then, I propose, we have embodied our tools. Indeed, this sense was also intuited by participants:

> *“We are kinetic beings, and we function in three dimensions and when you are working on the screen, although there are kinetic elements you do not have that fully rounded experience.” GL, female, 60 y.o.*
>
> *“At a certain point technology becomes like second nature. Moreover, that is when it is best because it becomes an extension.” GL, female, 60 y.o.*

NOTTOBEREPRODUCED, offered me the opportunity to bond as I had not done with the 3D printer before. Every piece was put at stake between certainty and uncertainty, showing mastery of the skills and technique and developing a tacit understanding of the technology. This came to a full realisation when I designed the 3D objects for the collaboration with the musician, I knew what the sound and noise was going to be as I was creating the geometry.

> *The skilled and sensitive human interaction with technology that is involved in poetic object making is arguably central to the maker’s art. A direct relationship with tools enables the maker to engage intimately with materials and process to create finished objects with a high degree of autonomy and control over quality. (Bunnell, 2004)*

To further inquire within this domain, I decided to do some creative experiments with workshops participants. These exercises consisted of co-located collaboration. This was executed in the same room, first with a hands-on material like clay or drawing. And using Tinkercad afterwards. The exercises aimed at creating something within a time limit to which every participant was going to contribute. In the end, material and digital creations had the certain flair for chaos. The aim of this was to look further in the development of a relationship with a process of making and trying to identify any critical difference when using the computer as opposed to modelling with clay or drawing. According to Dreyfus the way we relate to entities in virtual worlds is not the same as how we do in the physical world (Dreyfus,2001). This was demonstrated by participants who did not hesitate in distorting, appropriating and vandalising each other's creations when working with the physical models, whereas, the most extreme change using clay was some subtle addition and modification see figure 7-4 (this is explored in section 4.6). According to Sennett the skills we take pride on are those that take time to master (Sennett, 2009). Thus, establishing a bond between emotional attachment to our productions is dependent on time spent on them. However, the participants of this experiment used the same time frame for digital and physical activities, but they bonded more with the creations that required the exertion of physical effort than their digital counterparts. I argue that, despite accepting digital creativity and digital fabrication tools as a valid way of creating craft objects, there needs to be an embodiment of the technology in order to be considered as a "traditional tool on its own right" (Bottomley, 2004). The examples we have explored offer insight on the amount of time and devotion that "becoming one" with the technology requires. Perhaps, this embodiment requires to move beyond the old digital-analogue dualism, causing an ontological migration were technology is no longer a tool for modifying nature (Ingold, 2013b), but a way of being in the world (Heidegger and Lovitt, 1977).

Figure 7-4-"Desacralised" temple, clay collaboration, 2013, 12x3x7 cm.

Bending technology as a framework for collaboration

Although Wyat states that "we are all techno deterministic" (Wyat, 2008), my intention- as a technology facilitator, research observer, designer, technologist and a teacher- during the workshops was to become part of the activities in a neutral way and to try not to contribute to techno-deterministic agendas of technological development (Sporton, 2015). At the same time, I strongly relied on the notion of *knowing-in-practice* (Schon, 1983). Although I had a plan for every workshop, I was prepared to let go and follow the activities with an open attitude, adapting and deciding per the events and groups "in relation to the matter in hand" (Bourdieu, 1990, pp90).

This flexible approach allowed participants to "mess about" (Hawkins, 1969) and combined with easing the tension raised within the academic research framework. Furthermore, it contributed to the questioning and analysis of the research agenda as well as the design of the study. This proved a challenge and was a source of frustration. Hence, the decision to use low-level or simplified software was made, giving birth to the concept of *bending technology.* This term defines an ontological stance, by which I distanced myself from my own professional experience and *habitus.*

Bending technology, therefore, emerges from the need to communicate in a simplified manner and use tools that are accessible. Thus, the use of expert language and systems was diluted in the workflow by using different tools. The *rhetoric of disruption* seemed to counter the general intuition of participants to engage and explore 3D printing as if it were “just any other tool”, Morvern Odling. While they were exploring 3D printing, there was a perception of it being a “closed up” technology (Sporton, 2015). Moreover, those who were willing to experiment found a communication barrier in the language used by me as the researcher. In a meeting with a potential collaborator I used concrete terms to define the potential collaboration: “if you want, we can hack it” I said, (diary entry, 2014). This way of defining the technical challenges behind working with the technology made her falter on her intent to explore 3D printing. Although the participant did not agree on meeting a second time for doing a follow-up interview, I took note of how the conversation stalled after introducing the activities as *hacking*. Participant testimonies during the workshops and the longitudinal collaborations confirm that, in a way, the development of new technical skills can represent a hindrance for creative exploration of a given technology. This has been presented in the longitudinal collaborations.

This type of experience led to a simplification of the approach; to be more open in the design and conduct of interviews and meetings. This led to different forms of interaction where the participants were the leaders in timing and direction. This openness was challenging as a research strategy since only four out of eight collaborations developed to the point of experimentation with 3D printers within the timeframe of this research. Additionally, identifying a method for leading a practice-based project driven by participants, beyond traditional ethnographic and hands-off Participatory Action Research proved to be a challenge. To solve this methodological conflict, the researcher had to approach the collaborations as an open and flexible ethnography, combining the experience of the self with the advances in the different experiments, always considering that they could remain unfinished. The underlying strategy towards these low-key collaborations is represented below (figure 7-5).

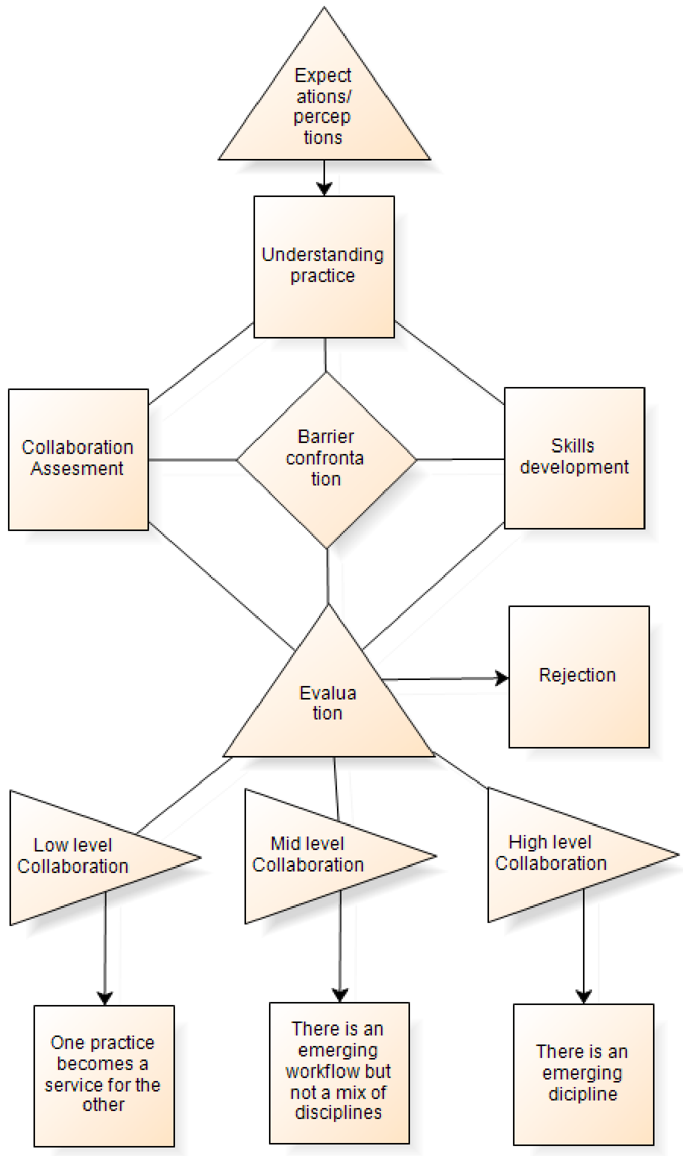


Figure 7-5-Bending technology collaboration flow.

8. CONCLUSIONS

This thesis provides substantial evidence that digital fabrication tools pose no more significant challenge to contemporary practices of craft than any other emerging technologies brought into modern ways of making.

Indeed, the alteration of modes of distribution and displacement of labour as we know it are common concerns in the history of technological dissemination. So it is my view of craft, aligned with the definition of McCullough, that ‘to craft is to care’: this reinforces the idea that where craft prevails(Greenhalgh, 2002), technology follows. Moreover, results in craft’s inherent duality that allows it to be at once both dead (Adamson, 2012) and thriving (Alfoldy, 2007). Indeed, craft is both a way of living and *performing tasks (embodied practice)*. As I have shown in this thesis, it does not matter what we are doing as far as we are cognizant that we are doing it. It has been my intention with this thesis to contribute to the debate about the role of the hand in the creative processes. More specifically, to contribute meaningfully to the debate about what it is that defines the inclination towards physical interaction with the materials and the role technology-mediated collaborations have in this.

Traditional perceptions of craft define it as a highly localised activity, even though materials are hardly endemic or restricted to place anymore. There is a romantic notion within this ‘Burkian localism’ that serves as a vessel to navigate contemporary technological flows. This romanticism can be seen to justify a philistine stance towards technology, that breeds a level of disinterest that can serve to denature technological development and create a more significant gap between technological generations. I believe that this causes a Human-Computer Interaction gap in which the lack of participation or experimentation with the previous technological wave decreases the likelihood of ever engaging with the evolutionary decedents of that technological family.

As voiced by participants, the kinetic relation to craft can be summarised as the feeling of imbuing the craft with physical effort. However, the boundaries lack a clear definition, and once technologies and tools are embodied, the technological process is no longer a communicational barrier. The use of tools and technology as a means of being in the world (Heidegger and Lovitt, 1977) and manipulating nature can be more easily reconfigured using collaboration, as evidenced in this thesis. Technology-mediated collaboration is at its best when it is intergenerational, mixing confidence and accumulated knowledge with willpower and an emerging set of skills.

Trying to answer some of the questions and debates proposed by participants during the workshops, I experimented with 3D printers using a highly physical and hands-on approach. I concluded that 3D printing could be used as "just another creative tool" that requires attention and care, and this can be defined as craft according to McCullough, 1998. According to participants, physical effort is required as a way of expressing oneself. However, this is highly conditioned to the level of openness and affordances that a specific machine might have. In our case - PrintrBot Jr V01 contributed to the development of a new practice by creating a textiles PLA hybrid. However, with technological development and increasing complexity this affordance can be limited, therefore hampering the possibilities for creative experimentation.

8.1. CONTRIBUTION TO KNOWLEDGE

The aims of this research were:

> *Aim 1: To capture perceptions and divisions generated by the rhetoric of 3D printing within creative practices in Scotland. Sub-questions; To Identify the gaps in the literature about digital fabrication, 3D printing, craft and making. What is the use of ICT technologies within creative industries in Scotland? What are the perceptions about 3D printing?*

> *Aim 2: To demonstrate the creative and practical benefits of collaborative practice as a mode of engagement with emerging technologies. Sub-questions; What are the barriers that creative practitioners encounter when using digital fabrication tools? What are the differences between generations of users? What is the difference between collocated digital collaboration and direct material manipulation?*

> *Aim 3: To articulate and analyse the role of direct material manipulation within craft practices as a factor for the dissemination of emerging technologies. Sub-questions; What is the relation between craft practice and direct material manipulation? Does*

collaboration provide a better opportunity for exploring digital fabrication tools? If so, what are the underlying processes of this opportunity?

The line of inquiry driven by the aims represented above led to the following contribution to knowledge:

- A survey of perceived challenges and strategies that 3D printing can pose to practitioners, and confrontation of issues therein.
- The identification of the notion of Professional Meddling and how it is perceived by the community of practitioners.
- Bending technology as a framework for collaboration based on the following premises:
    - Move away from academic and media narratives and vocabulary
    - Don't assume technology equals progress (Sporton, 2015; Wyatt, 1999)
    - Confront and challenge media narratives
    - Hacking and *bending* are a creative way of exploiting transgressing technological constraints (Jordan, 2008; Levy, 1984; Sporton, 2015)
    - Do not let the medium/technology lead the creative narrative (Myerson, 1997; Sennett, 2009)
    - Create an environment that fosters creative exploration and with a "bias towards action."
    - Individualise the experience when possible
    - learn and adapt to the capacities of the practitioners and participants
    - Allow "fooling around" and self-pacing of participants
    - Establish a dynamic that avoids being dismissive of traditional ways of making and crafts
- A proposed model of stages of discovery and decision making in technology that creative practitioners go through when approaching emerging technologies.
- A range of practical experiments that led to numerous exhibitions, awards and contributed to a research grant application; Adorned afterlife.
- The development of an active community around 3D printing within Edinburgh College of Art that led to the creation of a research centre that aims at exploring technologies within making; RAFT[60].
- Demystification of 3D printing and new technology within the domain of craft by working with a community of makers.
- A personal narrative that elaborates on the role of the technical advisor or mentor and that gives an alternative account of the *technical expert* within digital craft collaborations.
- An alternative understanding of 3D printing as a way of producing media and tools and supporting materials for developing or speeding other processes.
- The use of the "genealogy of the tool" as a framework for understanding distance to emerging technologies.

[60] https://www.eca.ed.ac.uk/research/raft

- A Body of practical work that demonstrates the capacity to build tacit relations with 3D printing and its materials. This is developed through the appropriation and remediation of the materials, by-products and processes of the technology.

8.2. LIMITATIONS OF STUDY

The development of a personal narrative provided the core of the research inquiry; however, other methods were used to limit the impact of my unconscious bias. In an attempt for gathering sufficient data I over committed myself to an exceeding number of research activities, thus compromising my ability to conduct grounded theory analysis between stages, hence shattering the possibilities of providing a compelling grounded theory analysis. The development of a personal narrative where I was at the core of collaborations offered many opportunities that differentiate this research from previous examples like Risner, 2013, and Jorgensen, 2017. However, I feel that my participants could have developed more independent lines of inquiry if it were not for my need to gather and analyse research data or if my position as the researcher had been more defined, as mentioned before; "According to Sandra Acker defining the position we are at as researcher is increasingly complex in contemporary research paradigms, questioning the ability we possess to identify when we are the insider or the outsider or something in between (Acker, 2001)." Section 3.4.

My research was focused on creative communities based in Scotland, and this has led to highly localised knowledge. For instance, the findings by McAuley and Fillis, 2004, and Yair, 2011, suggest that in England- compare to Scottish practitioners- makers are slightly younger and more inclined to experiment with technologies as a part of making and not just research or other promotional processes(McAuley and Fillis, 2004; Yair, 2011). This could imply that conducting my research in other communities could offer different insights as participants could have more experience with technology.

Most of the participants were genuinely curious about 3D printing. Hence, the demographics of my participants are biased towards those who were already willing to explore the technology. I failed to engage with people who did not have an interest in 3D printing, as discussed in the workshops chapter. This could be related to feeling that 'traditional' craft is deeply associated with a non-technologised practice. Although this would be opening up a discussion that does not belong here, it is interesting to highlight how and what is defined as 'traditional technology'. This could be approached as a hand-craft romanticism, beyond the expression related to traditional craft:

> *"Funnily enough, it is not the machine; it is the controlling part of it. It took me a long time to get to grips with the software, mainly I could not get it. I started with Tinkercad and, while it was the right choice, to begin with, I would probably use that to introduce other people. I use Illustrator and Photoshop, and there is a specific mindset for Tinkercad: it was dumbed down…it frustrated me it did not do all the things that I wanted it to do." Morvern, Textile designer.*

Beyond the physical outcomes, this research focused on challenging the preconceptions of those who perceived 3D printing as a potential disruptor. The data from the workshops identify the presence of unrealistic expectations, as well as proving that an initial encounter with such technology can alleviate hype-induced fears and anxiety. I have demonstrated that interdisciplinary collaboration provides a nourishing platform for the creation of new practices and that generationally-based technological barriers can be better overcome by collaborating with those of earlier or later generations, respectively. However, despite my best efforts to collaborate with a range of practitioners of all ages, the level of collaboration with practitioners of older generations did not reach the same level as when compared to younger participants. Differing agendas or busier professional lives seemed to compromise the opportunities for interacting. Alternatively, perhaps it was not perceived as a real opportunity to take on-board already well-established practices.

It is relevant to note that when I started this research (September 2012) there was only one 3D printer in the Edinburgh College of Art and it was hardly functional; it is difficult not to find a department that does not have one today (end of 2017). Even further, what was a mass media rhetoric of disruption has evolved into disillusion and disbelief[61]. Arguably, we are now in the recess of the hype around 3D printing. Independently of the ebbs of mass media hype, desktop 3D printers are increasingly becoming cheaper and easier to acquire (it is common to find very cheap 3D printers in superstores). However, it remains to be seen how far the creative use of desktop 3D printing evolves.

[61] There are examples from the end of 2014 of media reporters wondering about the poor economic stability of the desktop 3D printing market, i.e. Kharpal, 2014. Additionally, two of the mayor manufacturers of desktop 3D printers have discontinued their production by the end of 2017.

8.3. FUTURE RESEARCH

I started this research project with the intention of contributing to the understanding of traditional creative practices within an ever-increasing technological environment. I intended to support those who felt threatened or anxious about emerging information and communication technologies. I intend to develop the framework I defined as *bending technology* into a collaboration toolkit with the intention of better supporting those who aim at exploring emerging technologies within a creative environment.

According to Townsend, participating in design activities increases bonding with the design activities and the product (Townsend and Niedderer, 2016). Through my research, participants have voiced the need to be able to bond with a technology to build a creative narrative. The collaborations and workshop I ran with the aim of contrasting the influence of time on emotional bonding fell short to produce a deeper understanding of the cognitive processes behind emotional bonding with digital fabrication technologies, hence would a collaborative digital design activity produce different levels of bonding that a collaborative hands-on activity?

Furthermore, the line of inquiry I developed in collaboration could be extended within the domain of craft. Collaboration through craft remains somewhat understudied (Felcey et al., 2013), and the role that technology and the mechanisms for using 3D printing as a way of collaborating remotely but on hands-on activities are still to be tested. It is common among groups of engineers to share prototypes across the globe, and we have seen how the maker community share and modify their models, but what happens when two creative practitioners send models to be handcrafted? Could we expand on the notion of the trace of the hand with remote 3D printing?

The experiments started on textiles through WEAR3D have produced some outputs already, however, there is far more work to do. This research continues to produce avenues for inquiry, one of the most important is how printing on textiles can be used to produce protection from sharp objects wounds.

With this research, I have created an opportunity for understanding technology in flux, both in its evolutionary mechanical form and in the cognitive transition from disruptive, to emerging, to traditional. If desktop 3D printing lives to fulfil the expectations of conquering every home, it is sure to have an impact on our cognitive perception of space and geometry as well as challenging perceptions about materiality and the hand-made craft. Even further, what would be the impact on a person´s mind if had access to 3D printing from an early stage in life? Would the relation with the digital-material world alter the way we perceive material or the digital?

I have used the notion of the technological generation, based on the "*genealogy of the tool*" (Wiener, 1988) to develop a hypothesis about how when individuals disengage in the development of a technological family can lead to separation to subsequent iterations, thus creating a steeper learning curve and limiting the possibilities to engage with new technologies. Although I am confident of the theoretical implications, I feel that further research is required to confirm the findings. Given the limited number of participants that had gone through this process, I feel uneasy to reach to conclusions.

Measuring the impact of 3D printing and digital fabrication on craft -and hands-on practices- has been one of the lines of inquiry of this thesis. Perhaps this is not different from many other researchers and the fact that we aim at measuring the impact of technologies gives away that we are acting as techno deterministic as Wyatt suggests (Wyatt et al., 2008). However, I feel that an alternative, yet practical, view is possible. Through the research, I understood that emerging technology was being used as a means of exchanging skills and knowledge. Thus, being used as a language of exchange. It is my opinion that technology serves a community as a *pidging language*, that is, a hybrid language that serves a cultural or economical purpose between two separate groups that have no other means of communication than making a mediating system that serves as a platform for exchanging socio-cultural values, knowledge and objects. It is my belief that exploring technology as a language of exchange can open new avenues of research and insight into emerging technologies and more importantly the communities that support and give them meaning.

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10. APPENDIXES

10.1. APPENDIX A: RESEARCH OUTPUTS

Summary of PhD Contribution – Diego Zamora

I am a PhD based at Edinburgh College of Art, Edinburgh University. The title of my thesis is *Disruptive opportunity; the role of emerging technologies in the development of creative practices.* With my thesis I am trying to answer the following question: How do emerging technologies influence creative practitioners that use craft as a productive method and what is the role they play in technological dissemination. I intend to submit my thesis by September 2015.

Research Outputs

I have exhibited practice based projects in a number of places:

Zamora, D., Connolly, M. 2014. NotToBeReproduced, 3D printed material, art piece co-authored during a residency with Black Cube Collective under the ICT-ART project funded by the EU commission. Exhibited at: FoAM, Brussels, 10-12th May 2014.

Zamora, D. Oddling, M. 2013. WEAR3D; development of a hybrid between 3D printing and textiles, Textile art: PLA printed polymer, organic cloth, exhibition and public event at Edinburgh Gayfield Creative Spaces 20th August 2014.

Zamora, D. Oddling, M. 2013. WEAR3D; development of a hybrid between 3D printing and textiles Textile art: PLA printed polymer, organic cloth, exhibited at All Makers now? Conference, 10-11th of July 2014, Falmouth.

Authored and/or coauthored:

Maxwell, D., Speed, C., Monsen, K., Zamora, D. 2014. Designing a Digital Trickster: Using Folklore to Frame a Pervasive User Experience. [Submitted to CHI 2015]

Mehrpouya, H., Maxwell D. and Zamora D. 2013. Reflections on co-creation: An open source approach to co-creation In Participations Journal of Audience and Reception Studies, 10, 2.

Zamora, D., Monsen K. and Von Jugendfeld R. 2013. Crafting Public Space: findings from an interdisciplinary outdoor workshop on 3D printing. In Participations Journal of Audience and Reception Studies, 10, 2.

Zamora, D., Connolly, M. 2014, NotToBeReproduced, The State of Art – Sculpture & 3D #2 | Bare Hill Publishing (Expected publication May 2015)

Funding awarded:

Devolved researcher fund (2.900£) Funds for running PRINT3D, exploratory 3D printing laboratory. The aim of this project was to support the learning of others about 3D printing as well as engaging with the general public through exhibitions and workshops. (October 2013)

ICT-ART European commission residency (1.500£) The residency program aimed at exploring cocreation between artists and technologist. The project culminated with an exhibition and an oral presentation for EU commission president Jose Manuel Barroso on the 12th of May 2014.

Awards

Highly commended entry; Fresh Ideas Competition. Scottish Institute for Enterprise (SIE) 2015. *3D Tweed*, a collaborative project researching the development of an organic tweed based 3D printing material.

1st prize Launch.ed Business Ideas Competition, 2014. *3D Tweed*, a collaborative project researching the development of an organic tweed based 3D printing material.

Other connections/collaborations

I created and chaired [redacted]raft a network of practitioners and researchers related to digital fabrication, the network hopes to enhance collaboration and knowledge sharing across the range of disciplines related to these technologies.

Word of Mouth: Talking about how we interpret skulls (2014) Collaboration with Forensic Anthropology department of Edinburgh University and Surgeons Hall Museum http://surgeonshallmuseum.wordpress.com/2014/08/14/word-of-mouth-talking-about-how-we-interpret-skulls/

Health report on the use of 3D printers

Health and safety issues have been somehow relegated to a secondary level. Published research concerning direct environmental impact is scarce, although there is some literature referring to energy consumption and concerned with the low efficiency of the machinery (i.e. Baumers et al., 2011; Ullah et al., 2012). Some examples can be found within rapid prototyping; however, they are more focused on consumption and production rather than considering possibly dangerous emissions during printing. In 1999 Luo et al. developed a method for assessing energy efficiency, a “process model based on lifecycle” subdivided into “Material Preparation, Pattern Build, Mold Creation and Disposal” which could be used to evaluate any rapid prototyping method considering how “The material use, process parameters (e.g. scanning speed) and power use can affect the environmental consequence of a process when material resource, energy, human health and environmental damage are taken into account” (Luo et al., 1999). Although not directly applied to the use of 3D printing, it has served as a base for a later publication by Aleksandra Drizo which intended to raise awareness about the issue.

In her article, Aleksandra Drizo argues that doing elaborate environmental impact assessment has been inadequately approached, as the industry defended that it was not relevant given the relatively low level of adoption and spread of rapid prototyping technologies.

> “One of the most pressing issues in estimating the environmental impact of RP and RT technologies is to evaluate the potential lexicological health and environmental risks that can occur from handling, using and disposal of the RP [Rapid Prototyping] and RT [Rapid Tooling] materials. Since, the first RP processes deployment in the 1980s, numerous materials (epoxy resins, polycarbonates, acrylates, acrylonitrile/butadiene/styrenes, elastomers, nylons (polyamides), cyanoacrylates) have been developed, with new materials rapidly emerging on the market. Yet,

> although the need for materials standardization in RP industry was recognized five years ago (Waterman, 1999; NIST, 2003) the toxicity and environmental impacts of many RP materials (both "older generation" and new materials), and chemical solvents used for their removal, have not been identified to date." (Drizo and Pegna, 2006)

There is a recent review about safety by (Stephens et al., 2013) published in the Journal of Atmospheric Environment, where the authors reveal, in a pilot study, that 3D printers can be compared to previous studies on office printers. In this case they refer to (He et al., 2007) as a ground study for determining emission rates, to conclude that 3D printing can be considered "high emitters" of Ultrafine Particles (UFPs). The authors suggest that there is no reason for panic, as 3D printers could be of similar risk to smoking or the use of electric cookers.

"These results suggest caution should be used when operating some commercially available 3D printers in unvented or inadequately filtered indoor environments. Additionally, more controlled experiments should be conducted to more fundamentally evaluate aerosol emissions from a wider range of desktop 3D printers and feedstocks [Filament, the material required for 3D printing]." (Stephens et al., 2013)

10.2. APPENDIX B: DIARY ENTRIES

Compressed instrument pack

Tinkercad

NAVIGATING the space;

M wheel up/down zooms in /out.

RClick hold and move the mouse will rotate (Orbit the space)

RClick + Shift hold and move the mouse will Pan the view

Grid settings

Snap grid will make elements to "stick" to the grid

The dimensions are very useful to have a sense of scale.

IMPORT

We could import .STL (3D Models) or .SVG (Inkscape or Illustrator drawings)

Helpers

Working plane, help us keep reference to other objects or distances.

Ruler, really useful, we will need to add the ruler to be able to do precise input of measures.

Geometric shapes

Click or drag and drop. Geometric generators in some cases portray sliders or numeric input

How to move things

Click and drag to move things around

Click and Drag the top cone for moving vertically

Precise input

Once you have added a ruler.How to change the size of things

Pulling the white dots around it.

Press and HOLD Shift at the same time it will scale the object

Press and HOLD Alt it will apply a symmetric change

Boolean operators (Joinning things)

To create more complex geometries or objects we need to Group objects

Group objects and holes (any geometry can be a hole)

Aligning and mirroring

Align is very useful for making sure how we connect things

Mirror helps copying things or just making a mirrored geometry

Save and export

Despite the software auto-saves frequently it is good to keep "hard copies" of your creations as an .STL

Diary

Diary 10-04-2014

Workshops Health and safety audit Interview with the head of Health and safety

“well, [3D] printers go where they should - the workshop.”

Diary entries from workshops

Pilot workshop OLEUS

Notes day 1

Everyone was very keen, craft practitioners were a bit anxious about participating, specially about using computers. Once they started using the haptic devices (pressure sensitive tablets) they didn’t let go of them. Ceramist expressed a few times how it a relief to have such a nice and relaxed atmosphere. She expected a “bunch of nerds with expensive toys”.

Notes day 2

There was a heated debate about the role of emerging technologies and the emergence of amateurs and professional intruders. [omitted name] the ceramist referred to a group of people doing “naff craft” and doing loads of “laser cutting on Etsy”. For her -with the support of the other craft practitioners this was a challenge to their practice as often that people would sell a lot. Following this conversation one of the craft practitioners stated that 3D printing could be “fun for producing toys and small trinkets” but not to be included in his practice. HE is a stone Mason. So it is not a surprise that he suggests this. Many participants complained about the size of the printers and how small the prints were. Size seemed to trouble most of them and it was highlighted as one of the limitations. However, at the end of the day they all took loads of pictures and made the best of the textures of the urban environmetn, size can be compensated with numbers and images as one of them suggested.

Workshop A; 14 March 2014

Participants introduced themselves in a big circle, had to be prompted as they were all very shy.

A participant who is a luthier wonders how precise the technology can be and if it can have an impact on his practice. He later during a conversation “I can not see where the technology is better than me [technical information about the precision of the 3D printer] I can be more precise than that” He was disappointed with the technology. Found the design software frustrating specially Sculptris. Did not enjoy seeing his project being distorted in the group activity.

Two product designers, they are interested in the capabilities for prototyping. They reported at the end of the workshop that seeing “real life” practitioners working side by side was the most rewarding part of the workshop. “we want more of this workshops with more technologies”

Older participant constantly asked for help from a younger participant, this one ended sitting by the older one to assist with design in the computer.

An architect wants to see how useful 3D printers are for models and prototypes. He said at the end; “it was easier than I thought” I asked him if he would get one printer; “well, I think I will wait till next generation is out, I always do that with phones and works out quite well”

Memo- Audio recording at end of workshop

I am knackered, they were too many and should remember not to allow friends to come together to any other workshop. They just stayed together talking and doing their designs without engaging with any one not even me.

Focus group did not work, they were too tired and me too. Just answered with very short phrases my questions and did not engage with any of the more interesting questions.

Recommendation to myself; reduce amount of activities and simplify technical details.

Workshop D; 25 April 2014

Today they discussed how technology produces the same, following Dormer (think someone mentioned Dormer)

They said that technology was limiting in affordances, while looking at some of the samples of WEAR3D.

E; 2 May 2014

The group today is composed mainly by University Staff.

Discussions were very interesting although they were driven by the senior members of staff.

One of the lecturers stated; “I have to transfer this to my students” referring to the range of supporting technologies and workflows applicable when using 3D printers.

Note; some of them printed downloaded geometries from online repositories.

Workshop J 16 OCT 2014

Staff-the medium is the message discussed overtly during the day.

They made many comments about the aesthetics and how they could see an impact on monochromatic profusion.

Workshop K,

The recorder decided to stop working despite having spare batteries. So unfortunately, there is no recording of this conversations

Had 4 participants at the beginning of the day just 2 participating in the final discussion.

Was very playful and offered a very creative and dynamic activity.

Discussions were very interesting but there was only one voice. There was generalised agreement on the role of technology as an extension of the body.

Written feedback

10.3. APPENDIX C: TRANSCRIPTS FOCUS GROUPS.

Transcript Focus group OLEUS

DZ: I am really impressed about the level of participation. I want to use this time to get to know how you feel about what happened. I want to start a conversation.

DZ: Digital Confidence, thanks to the activities, as for instance have been scanning things…? First impressions, How did you feel?

Ceramist: I have learnt a lot from the software, I have perceived it is really easy; I am talking about Sculptris, which is a little bit too easy probably,

Silversmith: It has helped demystifying, for instance the barrier *older* people was perceiving, now I see it in a completely different way, now I perceive it as fun, if it is more like a chore… then you don’t use it. Now I can see quite happily how this could quite easily interact with my practice.

Ceramist:

Stonemason: I kind of agree with both of you, although is not a kind of revelation to me, I feel it something slightly more tangible, it is relatively easy to make something straight away. I suppose that applies to anything, a craft is something that take years to master () I see not just the software available for 3d printer, but the laser cutting as well, how the software links to the 3D printing, I see how it

Silversmith: it is interesting that you can still make mistakes, and that is part of learning as it is in the (craft?)

Stonemason:

Film Student: in terms of mistakes I wonder how interesting in terms of experimentation, like in the history of cinema in which many thing could be considered as mistakes, but is rated as the most interesting part of cinema history.

DZ: Playing with the technology and experimentation, to what extent the interaction with the material stops? When do you think that the link with the material could stop?

Stonemason: You mean in terms of ()

DZ: Where is the barrier in between handmade and not handmade?

Ceramist: The machine and the computer there is no hand intervention, this is why I am having a difficulty to understand it as a craft, is it craft?

10:03-Stonemason: If you look at some of this that make bespoke objects, Phillip stark?

Silversmith: But he is a designer.

Ceramist; How are they made?

Stonemason: yes, I presume that there is an industrial process,

Ceramist: There will be a craftsman presumably involved in the making

11:00 Stonemason: no, but there are many industrial processes is in a sense a craftsman, there is always someone making things with the hands, Silversmith: My practice is slightly diverse, when I think about what I want to make, I don't necessarily want to use those processes that are already at my fingertips, I enjoy visiting other studios and absorbing their processes. The process we have been looking at in the last days is as it is for most people, I see it from a different angle, and can I stop it and put something, could I manipulate it and become part of the process with the machine?

Ceramist: I have seen massive possibilities on this.

Silversmith: pushing a bottom and then letting it go is a great idea, but I can not let that go. I get bored just seeing things running. I don't see that as being wrong. I have the short of person that cannot let thing go along, I need to interfere. […]

15:00 DZ: We started a discussion about that on the first day, what was the use of it, is it good specific, does it offer an opportunity for exploratory practice? I wonder if it is a matter of age or not… I think we can offer a good contrast with the people present here.

We create objects

15:44 Stonemason: My brother visiting in Germany […] virtual realities, Stonemason: Yes, if you had something that was linked to your hand, you will be more involved senses of hands, and then that could be passed on to the machines, you would not need to transfer that to the Sculptris.

Ceramist: that is what I was thinking ,I told you, Diego, I was interested in the idea of making something by hand and then using the photography [Photogrametry] to capture It, to then printing it off, to compare the two, I would be really interested to see, are they identical? well obviously the materials are going to be different, does that have a handmade quality? Take it out in the street and say which one is handmade? Probably I could spot it but most people couldn't. Is that what you are talking about? That would be fascinating.

Ceramist: will the machine pick up that quality? and then expose it to public to see if people can spot the differences. I would probably will but would the rest of the people see it?

17:00-TH: There are technologies that can copy, then select the adequate technology to make the copy, 3d printing may not be the adequate technology. You will not see differences; you could fill it but maybe not see it with the eye.

18:30-Stonemason: I have seen on YouTube examples from a stone perspective, in which they were making copies of Michael Angelo's sculptures,

RV: they are installed in Florence

Stonemason: I was thinking not about making something which is then copied by the machine, is tanking the information with your hands, something that is linked to your hands and move them in the way that they are more engaged with the process.

Designer: But then the feel, by the touch you decide how the object is going to be formed

Stonemason: Yeah, but then considering your experience you will react accordingly to what you know and how you deal with the material. Clay, metal…

Silversmith: I got the feeling what is the point? You could probably interact with the machine in many ways; If I was to market it I would probably market a handmade objects rather that mass manufacture. I can see it being an interesting wee game. I can see that happening in medicine [] but for this level of manufacture, I think the point is when people want an object they want a handmade object, they want an interesting object.

Stonemason: What about of cars? They are really expensive and people is willing to expend crazy loads of money on it

Silversmith: I can see some level of craftsmanship at certain levels of car manufactures.

22:14-TH: The interesting part of 3D printing is the customization, I see a beautiful object, but I want to scale it and adapt it to my perceptions.

SV: I would like to add something from my perspective, Architecture, I work around tectonics, this representation could be made by a machine but the final outcome has that technique appeal, feel the material, the right feel to your art work, I think it is a tool… I think 3d printing is an approach to this tectonic field, to have a material feeling of otherwise digital creations.

Lorne: I suppose you could make some short of limited edition, print is still cheaper, but might get to more people.

Stonemason: unless it is handcraft crisps…

24:40-DZ: What if we created a file [] and we know that there is only going to be a limited edition of let’s say 5,

Ceramist: it depends what the edition is of.

27:00-Silversmith: it is the perception of how the artist is perceived as well; Emotional interaction in between the artist, I can see artist working in the way Jhon has described… Damien hart (he was getting someone else to it for himself) but at the same time you will be sitting by the side of Ceramist or Michael Heroes, Michael Roes, and make a flat piece of metal in a big sheet, How does that man do it? I guess a machine could do it, you are right in the sense that what is really nice about this there is an immediate reaction. For designers in particular is appealing straight ahead, but you are bringing the word craft, which is a completely different word.

Stonemason: But you could customise it, if you get something, if you distress it adding something you made of your own.

Silversmith: but doesn’t change the point, this objects are made is not about creativity is about the perception of the artist.

G: exactly, what happens with the perception of the artist; it can be mechanically reproduced…remaked objects it doesn’t need to be made by hand art can be mechanically reproduced.

28:30-Ceramist: that brings the art vs craft debate

G: but the if you think about 3d printing you have something that is mechanically reproduced and something that has been produced. but if it is about 3D printing we are bringing the 2 processes together produce and reproduce…

Silversmith: well that again Perception [film makers that are artists, and there are some others that are just film makers they are not at that level of acquaintance, here we are talking about 3d printing, 3d printing has already a baggage that is an industrial process, and that is up to the designer and the artist how to use it. And at the end of the day is about how they work with it . and how tey are perceived for the public that buys from them.

Ceramist: I was talking about accessibility about public and public acces. maybe is a great tool for making things more accessible, to make one piece might cost 1000 Pound, there is not a lot of people that is going to pay 1000 pounds for it, it is porcelain, fair enough, but maybe this one can make your work more accessible…making editions.

Silversmith: you might get a wage…

Ceramist: Absolutly… hehe

30:00-G: 20th century movies, is not about the cost of material or manufacturing, but the perception of how importatnt the ideas are and who made them.

32:00 J: Maybe there are things that there is point to have 3d printed, like something with a lot of detail it might be useful

J: for instance there were some limitations of the program, like probably we did as novices, as the same way you have to model something with your hands, you have to have years of practice, I think is the same.

34:00-Ceramist:???

DZ: Producing your own media and supporting your own media.

34:40-Designer: We were most of the time talking about differences but I was as well thinking about similarities, I think you share some emotions [..] if you were developing something with your hands you would like to have some short of surprises and that happens when you are working on the screen as well. When you do it you get your senses involved as when the design in the screen you are using your hand. When we took this it was a nice feeling, which might be different from seeing it like an end product…

37:00-Stonemason: but there is also, generations go by and get more used to doing things with computers and they will see it as natural, they will be used to engage with computers and then the production will be more emotional

Designer: that is exactly what I was trying saying; now I am more connected to this piece than if it was brought to me physically healthy and … get more senses involved would help you to be more attached to the object

Silversmith:My coment on [Stonemason idea of getting connected with his machine in which you will have a 3d arm] is, what is the point? Because each artitst develops their own skills and their skills are emotional, in the sense tof you become your skills; Your skills are you, you are your skills. each artist develops his onw skills. Because you obviously enjoyed doing that thing on the screen, and it look good from the beginning in the screen and we all thought that is the one. As it came out. In a way it was your enjoyment your skill, you were having frustrations as everyone else. Each artist develops his own skills, what you are saying reinforces what I was trying to say, of the 3 of us you came with the best design, [] I like working with Corel draw, and is because I am skilled with that and I enjoy that, I could see you enjoying doing that[] there is something about the human that we need to be creative.

-Jokes-

Silversmith: an asset, might be a good thing to have a noise about what you are doing

42:00 More comments, about how we did it… ?

Ceramist: I felt really nervous before coming here, I didn't know who was going to be here

Stonemason: I felt the same, I was quite open minded to give it a try, I find it fascinating, and somehow enjoyable

G: I don't have any previous experience with 3d design [] it was really easy to jump in to 3d knowing

TH: maybe I have the same problem as Diego, I am good with the non-organic shapes, working without scale, for me it was relaxing not to have the pressure of having to create something precise…

DZ: It would be interesting to see just the opposite, going all of us to the workshop perhaps to see a workshop or doing some activities…

Transcript focus group A

Focus Group A-Since the conversations were not flowing I decided to go back to analysing models.

(0:55) Design Student A, 20-30: I think in the future it will be like this.

(2:15) Craft practitioner, 30-40: Most of these are not really printable.

(2:21) Facilitator: Ok, so what we're going to do now- we're going to have a little contest, then I'm going to give you kind of guidance of what would be printable and not printable. And then I will give you almost an hour of time for you to decide what you really want or even get started to print if you already have something, alright? And then around 4pm we'll finish printing and we'll sit down for a brief discussion. And then I will let you go. So that is the programme so far.

(2:59) Facilitator: Anyway so let's have a look at this. Who has the project no.1? Alright, so that's what we've got there. How do you feel about it? What is that you created? What is that shape?

(3:17) Design student B, 20-30: Hmm that with the nose and two horns and a head. That circle is one of the eyes…it's just like a face.

(3:23) Facilitator: Alright so I'm actually going to open it, because we cannot really see it. Alright so here we have a collection of objects or geometries that are not connected with them or in between them so. You will see crazy loads of geometries and if you say print, it will try to print something – we do not know what. Alright, so first we will be grouping the geometries, so we need to click a group and make just one geometry of the geometries that are interconnected, or touching each other.

(4:32) Facilitator: If we group things that are not touching each other, like this one, then chances are the printer will understand it as something that is printable, but it will put it somewhere in space. And it will need a lot of scaffolding and support material to put it there. So it would be adding a lot of time to our print. And to remove the support material would result in no support material for the rest. So printability of the model 2/5. It’s not bad. But we are here to learn how to make it better.

Number 3, who created number 3? What was your intention?

(5:46) Craft practitioner, 50-60: I started off with a pyramid with two bits attached to it and somebody else built a village around it.

(6:06) Facilitator: Someone created something way out of the frame. So again printability – you know we shall join to things so we can print them. And actually that’s more printable than the previous one because there are no floating objects. Alright.

(6:25) Design student, 20-30: That we can see.

(6:27) Facilitator: Good point – laughing. Very good point indeed, sometimes you will load something into the printer interface and it will say it’s here and you will go nuts trying to find it. But people are creating some apps that will allow you to find them.

(6:57) Facilitator: Feel free to grab a chair, we are going to be here for a few minutes. Number 4, that was Bethany? Alright, what was your –

(7:21) Art student, 20-30: That ones doable isn’t it?

(7:23) Facilitator: This one is so far the most printable, we’ll need to put support material here depending on how big we make it. I don’t know if it is joined? No it’s not. So we need to group things so they become one piece. But that’s alright. This was a project created by a lot of people. So printability quite high, lets give it a 5/5.

(8:18) Facilitator: Aww what is this a broken heart? “Laughing” We can talk about that later.

(8:49) Facilitator: Who created this one? You? Alright what was your intention? Can you explain it?

(8:55) Design Student C, 20-30: Initially I wanted to make a plane, just two wings in between a cylinder.

(9:03) Facilitator: Alright and what happened? Normally the planes have wings that are spread like that, not like that. Is it an Egyptian thing? Alright, can anyone else explain what they were trying to do? Who worked on this project? I guess everyone else? Alright let's leave it like that. Printability? I prefer to keep it to myself!

(9:41) Facilitator: Alright let's go back to project 1, it ended up being tidy and neat; how surprising. So project 1 number 3, WOW, there is more to come apparently. Alright, nice that's some sort of mix in between a candy store and a garden. Alright, who created this? What was your idea?

(10:35) Design Student D,20-30: Yeah, I only did the little yellow triangle and the red blob "laughing"

(10:44) Facilitator: Oh! Alright that's fine, I see.

(10:47) Design Student D,20-30: Cool!

(10:50) Facilitator: Anyone else that can say how they feel working on this, explaining on the craziness of this model? I would actually order one for my house!

(11:04) Art student, 20-30: There's more than one object. It's just a wave of objects.

(11:09) Facilitator: Yeah basically it is just a collection of scattered objects. It's more like a kid's room after playing on Saturday afternoon. Ahh, we could print it, but again it would be separated objects.

(11:24) Art student, 20-30: So in this case the machine will print scaffolding between them as well.

(11:30) Facilitator: No it will make it as an isolated entity.

Another garden we have a lot of gardeners here. This is like a workbench, nice what is that? Maybe you need to go there with your broken heart. Same again, it's not a group but that's alright. To be printed it will need a lot of scaffolding, but it will be alright.

(12:38) Art student, 20-30: For the tree you'll need a lot of scaffolding.

(12:41) Facilitator: Yeah and it will be tricky and complex. I've printed some trees like that, when you are breaking away the support material the scaffolding material can sometimes break the branches. So it's a bit tricky. But if you make it huge then you can remove the support material and not break the branches. Lets go to the next one.

[…]

(14:03) Facilitator: Good, I love looking at things from this angle. What is this?

(14:07) Design Student D,20-30: It's a roof bar.

(14:12) Facilitator: Is that your invention? So it's like a normal garden on top of a tiny piece that is coming through a really weird thing? Alright nice, again printability, that will be fine to print. But you will spend hours, vertical objects tend to take longer than horizontal objects. And it's basically because you need to build more scaffolding the higher you go. And because it travels faster on the horizontal plane.

(14:58) Design Student D,20-30: So those type of objects are printable?

(15:02) Facilitator: Yeah, they can be printed in 3 minutes/ 5 minutes. Whereas this itself, although it is in pieces, I think took about 3 hours. So you see the difference: the higher the print the longer it takes. So we have one more? Who created this? Nessa? Are you happy with it?

(16:04)Art Student E,20-30: It started as a metal bracelet, but.

(16:10) Facilitator: Oh wait there is more. That is very nice, alright, yeah! So again, you didn't group it but that's alright we are learning about it. The shapes are having very thin lines of contact which will be challenging to solve. So this will need to go all the way in, but for the rest it looks alright.

(16:40) Actually this head at some point, not this one, but half the print time will be building scaffolding for it. So when you make things like that it takes much longer. Sometimes having a big nose makes it very hard. Alright so let's mould, so which one do you want to save from project 1? I mean I'm going to save all of them.

(17:17) Design Student D,20-30: Save for what?

(17:18) Facilitator: You know I'll be running more workshops and there will be more groups coming. And my original idea was to give at least one person, one of these objects. To see what happens, how it evolves through all the workshops.

Project 1 number 3, hands up? Ok

Project 1 number 4, hands up? Alright brilliant.

Project 1, number 2? Nobody

Number 1? I assumed it would be. I'll write it down.

(18:06) Craft practitioner, 50-60: As long as you fix the nose though.

(18:10) Facilitator: Yeah if you want to, feel free to do it. If you want to retrieve the designs do it at any time. So it was 3 or 4 votes for number 4, so we have a winner it's number 4.

(19:12) Facilitator: As I said, I'm going to let you go and play with any software you want for almost an hour. If you want to leave with a nice print, I'll try and get to the printer before 4pm. Otherwise if you want to make something really specific, you can come back another time or to the lab where the printers are located.

Transcript focus group B

Focus Group B

(0:05) Facilitator: Alright, so there were some interesting conversations already coming up. So one conversation started this morning, but we'll leave that for later. I want to actually hear something about – you know we've done an experiment in which you create something and then give it to someone you know and ask them to modify it. Well, what about when you put things on the internet? How would you feel seeing your creations being modified? I mean you didn't develop a really strong relationship with your things now. But you've been dedicating some few hours a week and then you put it there, and it is changed. One of the things that happens in Thingiverse, is that you post something and then it gets duplicated, remade, changed and at the end you sometimes loose the name of the thing you created. So how would you feel about that?

(1:24) Architecture student, 20-30: I don't think I could put it out there. Unless I knew that I didn't have my heart and soul invested in it because I've seen it happen too many times, with open source stuff or for architecture models.

(1:37) Craft practitioner, 40-50: I actually don't really think I would mind, because the thing is I know the original because I've done it and I would have my copy. And also you could see the potentials of what you could go with, which you couldn't necessarily do yourself. I quite like the whole thing of creative commons.

(1:58) Architecture student, 20-30: I think you could keep a copy and then you could watch it change. And note what were good changes and what were bad because there are bad changes. But generally it seems like you get good changes.

(2:11) Craft practitioner, 40-50: And just getting ideas out there is a way of distribution of ideas, and allowing people to have something to work with and seeing where that goes. There are loads of things that wouldn't happen if it wasn't open source, hacking, just alternative ways of working as opposed to restraining it. Then the whole idea of copy right and intellectual property comes in right?

(2:37) Facilitator: Yeah

(2:38) Craft practitioner, 40-50: It depends on how to whole idea gets used and when money starts coming into it. I think that's when it gets problematic. Because if someone is using an idea that is predominantly based on yours then how do you measure by how much. And making quite a lot of money out of it, you might think that's my idea: so how does that work? I think it's actually the money aspect of it.

(3:07) Facilitator: Yeah sometimes money causes the problem. Sometimes it's like saying: I've put that on there, it's grown that far and it's very nice. But if money comes into the equation, it's like; alright I've done that, it's grown that far but they're getting a lot of money that I'm not.

(3:26) Craft practitioner, 40-50: Yeah so who's the author? But then again nowadays you can the question who is the author? What is authorship?

(3:35) Design Student, 20-30: I think it comes down to what is the original object? And if it's purpose and form and function are still there. You know if I made something and I put it on Thingiverse with the knowledge that you put something on Thingiverse and someone will change it. If they then changed it and said it was theirs, but the object retained its original function you know; it was still a recognisable object, I think that's my intellectual property and yes you've changed it, but I had the original idea and that's where I'd have the problem. If someone had tweaked it slightly, I think it depends on how far you've tweaked it.

(4:24) Craft practitioner, 40-50: I guess it also depends on your intent as well, there's a sound performance designer, he studied sound design here. His stuff is amazing; he hooks up software to his body. But he created this software and hardware and he's made it open source from his website and I just think that's really brilliant.

(4:54) Facilitator: Yeah you see that quite a lot, most of the modifications are there for free. When you are posting to Thingiverse it will automatically offer you a list of the creative comments/ licenses you can put onto it. So you are already registering with creative commons how far you want to go. It's one of the really interesting bits.

(5:31) Design Student, 20-30: But then looking at what 3D printing is; is this restriction with the creative comments coming through (Flickr) is that restricting the experimental nature of 3D printing? Has that come in too soon?

(5:54) Facilitator: Perhaps, I think that depends on how you interpret that, there are a range of choices you can go for so it will change a lot from person to person; how you see your creations being put there. That view would depend on which project I'm working on.

(6:21) Architecture student, 20-30: It would depend on what it was, because I work for the office that helps student entrepreneurs. And you'd be surprised how many people have million dollar ideas and they're like 'oh I'll put it on the internet'; you put it on the internet; you can not make any money off it now because you've released it. So I guess I come from a background where I have this little bit of caution about releasing things. Like you could maybe release some things but if it's something you want to work on for the next 10 years of your life don't release it!

(6:56) Facilitator: Unless you have something really solid.

(7:00) Architecture student, 20-30: Some of the sound guys were releasing their master's projects. We had a girl who had something that would have been worth a lot of money. And she didn't even think about it, she released it to the world and she has no right over it, even though she's the one who invented it. But it cured ringing in the ear: it's a way to counteract that so I guess she's helped lots and lots of people so I guess that's good. But she's never going to make any money from it.

(7:39) Facilitator: But you could look at the original creator or developer of Linux; he's doing very well and it's an open source operative system. But to get back to the materiality, something you said: what's the original?

(8:01) Facilitator: For instance, when you are 3D printing and when you've brought something from the internet, where lies that connection with the original piece? What's the original or what is the meaningful part for you? What I want to know is, what is the meaningful part for you where is the interest? Is it the object, did you just print it? Or is it the digital model (note: that is interesting to you)?

(8:36) Architecture student, 20-30: The process, knowing that something started there and made it here through several different software programmes and then came out that machine.

(8:50) Design student, 20-30: It's the physical form because for example if I want to make this one it's easy for me to make it from wood or another material. But in this way I can just try to evolve it. I can try to modify it again and again, so it's kind of like some update for a physical form. Instead of, if I made a single one I can not do it next time, it's quite difficult for me.

(He's saying when one model is made, he could print 100 instead of making 100 by hand). I also think it's quite dangerous if we release this 3D model because I heard, news about a gun, people can print a gun.

(9:37) Design Student, 20-30: Yeah, 3D printed guns.

(9:38) Facilitator: But that's high level printers.

(9:44) Design Student, 20-30: The science museum proved it, they printed…they got the model design of it and printed it on one of those (ultamaker) and it exploded. They've got it on show, the bullet cartridge wedged in the barrel. Unless you've got top of the range V & A type money. The V & A bought the rights for it (the gun 3D model) from America. Because they are collecting design based works now. Printed it in America and America went 'you needed a gun export to print this', and the V & A can not have a gun license. So they bought the 3D printer, shipped it over here and began printing it.

(11:26) Facilitator: They are very good at collecting. They have realised the trend and probably are buying many other things. It's interesting (the V & A) is realising the trend. (12:02) So what do you think of it as a movement?

(12:07) Design Student, 20-30: I think it's got a lot of potential. One of the things I'm worried about is it's going to be one of these fad ten year things and it's going to disappear. It's not going to disappear from medicine and industry, but from a cultural point and looking at how it's being used in the cultural industry; I'm worried that people jump on the bandwagon and the technology isn't going to be advanced enough to support what the cultural sector want. What the museum sector want to do, I've seen some of the experimentation and the technology won't do that unless you want to pay £65,000 for a printer. So although I think in some cases it is here to stay, I'm worried that it's not going to be from a museum point of view; it's not going to stay. But then there are a lot of artists who are coming through and I know that Baltic are looking into showing 3D printed artists. So from a gallery point of view it's coming through as a major art form. But museums and galleries are very separate. Are you going to say why?

(13:57) Facilitator: Not why but if it is an art form, why do you think it is such a thing? (my words: or why do you think it could be considered as an art form?)

(14:04) Design Student, 20-30: It's a creative practice, you're creating something, it's a tangible object and with some level of creativity and thought.

(14:21) Craft practitioner, 40-50: Does that make it art then? But then you could question what is art?

(14:31) Design Student, 20-30: Anything can be art, as long as you justify it as an art form. It's got a creative input, it's got a creative output, it's got imagination to it. Just looking at what we did today for 5 minutes, there's no thought going into that; it's the shapes.

(14:52) Facilitator: Were you not thinking? You were supposed to think a lot. Would you see it as an art form or a platform for art?

(15:21) Architecture student, 20-30: I think it's a platform and I think everything that comes off of it is art.

(15:28) Design Student, 20-30: 3D printing is not an art form, but the actual objects you create through 3D printing technology is an art.

(15:34) Architecture student, 20-30: It could be an art form though if you were having experiential movements being printed.

(15:41) Design Student, 20-30: Yeah and if it wasn't about the object, but about the machine.

(15:44) Architecture student, 20-30: And the object came out of it, but I think there it was more performing art.

(15:49) Facilitator: So moving more into the performing area?

(15:54) Architecture student, 20-30: I think the process could be art, but not every time you run the machine are you doing performance art.

(16:22) Facilitator: Based on what is going on in the National Museum in mid-April; it is called Man versus Machine by Jo Wilcox. And basically it is a group of three 3D printers and three humans and they will have the same design and they are supposed to make it in a certain time. It's more about the performance of building the things, rather than confronting the actual creation of whether you take a lot of time or not.

So I normally try and approach craft practitioners and this is start to sound a lot like that. And today you're going to be referencing back to the performance. For a craft practitioner it is no longer about the final piece but rather about the process that you follow to get to that piece. It's quite interesting that you (i.e. the group) said that to what extent would you consider yourself to be a craft practitioner? Were you understanding you were crafting a 3D model?

(18:12) Architecture student, 20-30: Yeah I think so.

(18:14) Facilitator: Ok, would you agree on that? (Facilitator asking the Chinese boy) Would you agree that you craft your 3D models and your 3D print? So you put a lot of time and effort into a model and you print it, would you say that that's a form of craft? Are you making things?

(18:33) Design student, 20-30: Yes.

(18:37) Craft practitioner, 40-50: Yeah, craft is a funny word though. Craft and art: there's always a contentious issue.

(18:51) Design Student, 20-30: I'd say design rather than craft.

(18:55) Craft practitioner, 40-50: I'd say there's a craft to it. The way you manage it, like within fine art practice it's like developing the knowledge, skills and expertise in that one area so it becomes a developed practice and a developed craft. But I wouldn't say everything that comes out is contemporary craft. It's the idea of using it as a process or a practice and you can use it to make. I don't like discipline divisions, but to make more of a fine art or contemporary object; or architectural, illustrative. Or it could be a bit of jewellery; which is a jewellery craft object.

(19:56) Design Student, 20-30: Then 3D printing just becomes the medium or the process in it, so is 3D printing going to become this platform for art, or is it going to be an art form as a process? As a thing itself?

(20:21) Design student, 20-30: Yeah, I agree with you.

(20:23) Design Student, 20-30: What's it going to develop into?

(20:26) Craft practitioner, 40-50: Probably a bit of both. I mean who would be the people to question the actual process or be critical of it? It would probably be people in the art area who would take the process of it, more than seeing it as a final object.

So you were talking about generating sound from it, or looking at how it was made; the process of actually making the machine. So it's the focus on what it represents; maybe it's history, where it's going, all those questions that come with ethics. So it's what is entailed in this thing as the object; not actually the object it produces.

(21:27) Facilitator: But there is something really interesting in what you're saying; how does it influence the use of technology within a process in the perception of the outcome? (rephrased: how does technology influence or fit into the existing process? How does technology effect the process and ultimately the final outcome?)

You said 'I've seen it be a part of fine art: so why couldn't it be craft, if you're using that technology? Actually let's define craft as handmade or if you like we could try to define craft, that's going to be hard. But what is your understanding of craft?

(22:11) Craft practitioner, 40-50: Yeah I know I shouldn't think this because it's really bad, but craft is the handmade. But then you have to define what is the handmade because maybe over time that's changing now. Is it, I'm literally using my hands and putting it in a mould? Or the fact it's coming out a machine or that I'm feeding into an intermediary: obviously being a machine and then that is actually the production of it. So does it matter who the producer is? Is that what defines craft? With new technology coming in do we have to question and redefine craft?

(23:09) Design student, 20-30: Because craft is this unique piece that you can not copy, so you feel like it is different. Like handcrafted glass; it may have the same look, but it is different inside (note: each piece is made and produced separately in a handmade process which results in a higher margin for error). So 3D printing is also trying to create something unique because even though you can copy it, it is created by a single person not mas produced. Because if we turn to mass production we can use other ways other than 3D printing that are cheaper and better high quality. So I still think it is handcrafted but slightly different and in between because we use technology to help us a lot.

(23:59) Craft practitioner, 40-50: Yeah and because you can duplicate it, are they essentially the same?

(24:07) Facilitator: I must say, higher level machines might do the same print but I've tried to print the exact same thing so many times and I never get the same result. And what I'm looking at is how we can modify the process in order to not exploit that. So you can intervene within the process so your digital files are the same, but the outcome is different.

(25:00) Design Student, 20-30: In past we've defined craft through very tactile processes, because we've been involved with our hands looking back at all the practices I've been involved in. And now you've got this digital age that is emerging, I think you're right: we need to redefine what craft and the manmade is.

(25:34) Craft practitioner, 40-50: Maybe a new definition or get rid of craft all together.

(25:40) Design Student, 20-30: With 3D printing it's not just about the outcome: it's about the process just as if you look at sculpture. The process in which you go through in sculpture very much defines the outcome of what you're producing i.e. if you're using coiling or kilning. If you turn that into 3D printing; different resins, thermal extrusion, colours you use…the outcome is going to vary. So we need to redefine what handmade is. My perceptions are going 'it's not handmade because it's not tactile' but then I'm looking at all the theory and it is (note: handmade and thus craft).

(27:02) Facilitator: If we were ready to oversimplify and say craft is about the handmade. What you just said is a way of simplifying what we perceive, because if you discuss this with craft practitioners they'll say it's not handmade. So if we were to say this was handmade, where would we say the hand stops having contact with the material? Does the technology prevent something from being handmade? Think, what is the difference between something that was ‘handmade’ in the first century and ‘handmade’ in the 21st century?

(27:53) Design Student, 20-30: It’s that tactile engagement with the object and the actual material that it’s made with.

(28:01) Facilitator: But you are thinking about digital making?

(28:03) Design Student, 20-30: Yeah

(28:06) Facilitator: But you’re just thinking of the 21st century. Think of pottery; first century and 21st century? What was the difference?

(28:19) Craft practitioner, 40-50: Well you’re using an electrically powered wheel now.

(28:37) Design student, 20-30: A better material made it before (first century)?

(28:45) Architecture student, 20-30: The material is not nearly as local because you’re likely ordering the best clay for what you want to produce, rather than the clay that you get down by the river.

(28:53) Facilitator: If you were talking to a master craft/practitioner they would say a master crafter makes his own tools and uses local materials.

(29:09) Craft practitioner, 40-50: is that applicable now? Not really. It’s like in the olden days making your own paints from scraps and grinding the stone. It is amazing to go through that process and use it to paint with. Which is a totally different thing than buying acrylics. There’s an extension of yourself, it’s more gratifying.

(29:55) Facilitator: There is a moment in which they started the mass manufacture of paint. And they started producing more paintings that before because they didn’t have to have someone else in the studio making the paint. You could spend a whole week just making a set of colours. So simplified technology is behind our practice.

(30:37) Craft practitioner, 40-50: Sound design and music is a similar thing, (note: musicians look down on sound designers). The issue between what they consider is creation and sound designers are pissing about on a digital platform. Whilst the composer has instruments and his work is not digitally created. People have that issue with digital creation.

(31:29) Design Student, 20-30: I think it comes back to the definition and if something's tangible.

(31:36) Craft practitioner, 40-50: Goes back to the object and the material.

(31:42) Design Student, 20-30: The materiality of an object is really important. We talked earlier about bones; we were doing some work in Newcastle with 3D printing bones. If I put a 3D printed white bone in a museum I don't think anyone would notice. But if I put a green plastic bone in there everyone would go mental.

(32:56) Design student, 20-30: I think technology can change the definition of tools and craft. Five centuries ago we can not print anything. The printer we can define nowadays differently as a tool. Nowadays we print in different ways. How to copy books, if you have a digitalised file it means you can copy almost the same one as the original. But there are different papers and ways to assemble them together. So copying has been redefined.

(34:00) Facilitator: When there is a transfer from the digital to the material thing.

(34:09) Design Student, 20-30: Does that come down to how we value objects? If you've got a 3D object: it's tangible, tactile and you can get attached to it; but if something's a digital file it's away, you can not see it. You know it's always going to be there you know there is no corruption, it's always going to be there it has an infinite life. But I could break this at any time and once that tangible object is gone it's gone forever. Whereas with the digital aspect of 3D printing: 3D printing has an outcome but if this was 3D printed it would be exactly the same and no one would know. The chances of me finding a mug with the exact same inscription are rare.

(35:55) Facilitator: I understand that but there is something about industrial production too. Look at these chairs, if I break this one and hide the remains, no one will notice because there are others.3D printed objects are working in a different light, it's about the perception of replicability. We are talking about elements that have been made by someone and it is a one off. That's increasing the difficulty of finding something. You can potentially digitalise anything, it represents grabbing this mug and saying I'm going to break it in 3 minutes but first I'll make a copy. And then I have a digital file to represent something that is gone.

(37:54) Architecture student, 20-30: There's a ghost element to it, what you've printed before, what you've scanned, what you could print again and they're not exactly the same, just ghosts of each other.

(38:10) Design Student, 20-30: So you think a 3D printed object would carry the meanings of its past object?

(38:26) Architecture student, 20-30: I'd say if it was a replacement and you knew it was a replacement, then maybe. I think if you had never been introduced to it before then you would have no memory of it.

(38:43) Facilitator: Black mirror, one chapter is about her husband getting replaced and because so much information is stored in digital databases, there's a company making replicas based on all that information.

(39:47) Craft practitioner, 40-50: They use past emails so the phrases they use sound like them.

(40:09) Facilitator: If you were a heavy user of Facebook, twitter or Tumblr they're saying we could basically replicate you and the way you think and act. But it made me think about that.

(40:37) Design student, 20-30: When I was quite young I would think about a movie where from the corner of the world they tried to clone people and use their organs. Maybe some day we could do that and replicate ourselves.

(41:10) Facilitator: What are we loosing in the transfer from digital to the actual copy?

(41:19) Craft practitioner, 40-50: It's the touch with the hand, the direct contact. That assimilates in processes and obviously with this you still need to press the button. And you do need skills and expertise.

(41:45) Facilitator: And your hands are still very used, what you've done today, some people would struggle with for weeks because they couldn't move the things in space.

(42:00) Design Student, 20-30: You said something interesting, you said 'what you printed was not what you imagined', I think when you design something it's on the screen but you have a perfect idea of what it looks like and when you print it, that kind of wonder and illusion and mystery about what that object is going to look like is lost. Because this print was not what I imagined, and I think once you've got that tangible object it's definite; I could never change what I see in this because it is here as a form. But once it's on the computer screen there's still possibilities. You're loosing that mystery when you finally print something out.

(43:25) Craft practitioner, 40-50: You always have to go back to the file, the object is done now.

(43:43) Design Student, 20-30: Yours is a good one, you imagined this plaque and you've got a square "laughing".

(44:04) Facilitator: So there is some experience behind it as well, you still had the skills for this.

(44:09) Architecture student, 20-30: Because I've done lots of modelling not 3D printing. And my print measures exactly I wanted it to be 2.5 cm.

(44:37) Facilitator: And that's one of the things I think 3D printing is going to bring: kids growing up with 3D printers will develop a different relationship with 3D files. If you grow up seeing how things materialise, then you'll know and actually an architect knows better how a 3D model is going to look when printed.

(45:10) Craft practitioner, 40-50: Then I wonder, if that way of thinking has already set the parameters. So I'll think within boundaries; it's this and then it's going to that, I wonder how that shapes your thinking as a whole. The first time you think you can not do it, the next time you'll be a bit more considered.

(45:59) Facilitator: I'm sure it affects the way you think. I'm looking into how technology changes the way you think and one of those things it affects is the handmade. For instance, one of the things you said before; it could be comparable to a book or a movie (Chinese Guy's quote). There is still some interpretation, but it is a movie in which there is not much room for imagination. So to some extent we could say that you are loosing some of the creativity that is interpreted in the digital file?

(46:50) Craft practitioner, 40-50: Yeah! I engage a little bit but not too much and I get frustrated because there's something in here (points to brain) and if I knew it I could just draw it. But if I go to a software programme and I don't know it to an advanced level, you are pushed into a corner. I don't think you can really do what you want. There's that thing between here (brain) and here (software programme) that has to go to there (3D printer). When I'm drawing I can go 'Shit this is rubbish' and go however I want with it because it's immediate.

(47:45) Design Student, 20-30: If I took someone who'd never drawn before and someone who's never used CAD, the outcome would be pretty much the same. It's not immediate but a level of training and understanding you've had. You have to go through the tools and the processes.

(48:36) Facilitator: You do tooling as well with your hand.

(48:43) Design Student, 20-30: You have to learn to draw perception. If I want to tone or shade something on my computer, I can click a button and it will do it for me. But if I want to tone and shade a drawing it's going to take me hours. So technology is more instantaneous in regards to the outcome as opposed to the original process of drawing.

(49:26) Craft practitioner, 40-50: Maybe it's also the idea of perfection and imperfections.

(49:32) Facilitator: One of the common things you hear about technology is there are many errors that go on. And what a craft practitioner will explore (as part of their process) are the errors. So how you navigate errors you make while making is what makes a piece different.

Transcript Focus Group C

Discussion about Tinkercad

3:22.4 [they share something designed by one and then share it and others manipulate]

[We analyse the first model, printability is low]

4:05.5 Ceramist, 50-60; I started the happy Easter and then someone added swearing.

Facilitator. is it close to what you wanted?

Ceramist, 50-60: no one deleted anything, just added.

Designer, 20-30: I deleted.

5:26.3 Facilitator: I know [omitted participant's name: photographer] started with the geometry... Who added the eggs? What do you think about what happened with your design?

Photographer, 20-30: ooo I like it, the star doesn't make sense, but is nice

7:20.1 Facilitator: C3... uhhh (laughter) who started this one?

Designer, 20-30: I did... the result is interesting, but I did not expect some of the features.

10:09.6 Facilitator: project C4… you know you can rotate things? who created this originally?

Design student; I created the valley and then [participants name] added pacman and at the end I tried to make it more printable.

15:03.8 Facilitator: Are you the only one who deleted anything?

Photographer, 20-30: I did delete somebody else's, only to make space

Ceramist, 50-60: I did delete something else too that was lying around, not joined with anything else...

Facilitator: How did you feel when you were deleting things...

Ceramist, 50-60: like god. [jokingly]

Facilitator: how did you feel when someone deleted parts of your creations

Designer, 20-30: probably if I was making something serious, and something pretty, I would feel quite annoyed, but since I was just adding bunny ears… I did not even notice they were removed

Facilitator: there is something interesting about this... so if we upload a design. Someone might change it or modify...

Designer, 20-30: that's why you have copyright

19:54.9 -Thingiverse and online repositories-

20:29.5 -Analysis of previous groups work- Including luthier's creation...

24:31.7 -Easter town voted-

Final discussion workshop C

(0:19) Facilitator: What did you say about mass producing?

(0:22) Designer/craft, 40-50: Kath was just saying, clay is cheaper because you don't have to buy all that stuff (referring to the plastic reels). But if you are mass producing something, obviously it's cheaper to print a plastic model.

(0:32) Facilitator: Yeah well that's one of the things they are saying about 3D printers: how it's going to influence mass production and actually they say that it's…you've probably heard about mass customisation. They are talking about mass customisation becoming one of the bigger changes in industrial production. So they are envisaging the future of industrial production as a huge planet with a huge number of 3D printers which will be able to produce many different objects at the one time. When you go to an industrial plant they are normally producing one or two things; it's quite limited. Whereas if you have 3D printers you can be creating as many things as the printers you have. So that will open a new way of exploiting the machinery. And each thing you are printing could be different.

(2:21) Designer, 20-30: At the same time, it can be identical. There be fights about copy rights on the internet; copyrights there. Since I can print Lego blocks if I want, what stops me.

(2:44) Ceramist, 50-60: If you were mass producing kitchen sinks; they are all identical and it's probably going to be cheaper doing it in the old technique. But if each person wants one some personal name on it or a unique pattern for the bathroom then. It's also laser cutting; it's everywhere now, every degree show has something laser cut in it. Whereas ten years ago the student would have got an A if they figured out how to use a laser cutter. It's coming faster than we know.

(3:31) Facilitator: Yeah, actually you started seeing a lot of 3D printing at the degree shows. But it's quite strange for me, because it is common to see projects that claim to be the first in doing something; so they designed ballet pumps (shoes)…they designed them and 3D printed them and said 'these are the first 3D printed ballet pumps', that was the only thing they were making. That's my problem, with the use of new technology you can claim it is real.

(4:38) Ceramist, 50-60: Or you think it's better just because it's the first one. I notice the amount of times you see a sculpture advertised as the biggest and it doesn't have to be the biggest it has to be the best.

(5:06) Facilitator: We are going to be the first people to make something with clay and 3D print it.

(5:14) Designer/craft, 40-50: But then what's the point of 3D printing something you've already got in clay? It seems like the point of 3D printing is to print stuff that isn't 3D.

(5:27) Ceramist, 50-60: I feel like that as well.

(5:28) Designer/craft, 40-50: To be honest I always think it's about visualising something that's not present. It's already there.

(5:36) Ceramist, 50-60: Yeah, well yours would crack when it dries out, because it's got some thin bits on it, whereas the 3D plastic would be a bit more durable.

(5:06) Facilitator: There's something I didn't tell you about laser scanning, for instance if you try to scan this: I will end up getting a really good scan of this area, but I will get some errors here and there is no way I can get inside of this. So how the laser scanner works, I'll put something in a plate and the laser will be looking at it from the side, it will spin around;

register that geometry and then go up. So the problem here is that this geometry on this side, would be hiding the other part of the geometry and there are points it will never reach. So there will be an interpretation of what volume you are creating, for instance if you have undercuts or things like a bowl, it will not work.

(6:45) Ceramist, 50-60: What we did with my thing was scan it on an angle and scan it on another angle, but it didn't work very well.

(6:59) Facilitator: I would try to scan it flat.

(7:50) Facilitator: Oh is this what you're making?

(7:52) Ceramist, 50-60: Yeah it's a book of architects that have experimental drawings from the 1920s. They're real architects, I really like the idea that they did something so illogical. I'm quite interested in things that you can not quite sculpt. Why do people make stuff as mad as that?

(8:55) Facilitator: If you want to laser scan anything, bring it early next week. Or we can scan that.

(9:06) Ceramist, 50-60: I'm a bit of a control freak I'd have to make it again.

(9:30) Facilitator: Can you compare both processes? In both cases you were under pressure and I was trying to alleviate the stress in both cases. But in which case were you feeling better, if at all?

(9:47) Designer, 20-30: It's probably a matter of practice. Both processes would be equally difficult since I don't know how to use clay and 3D programming. But for Kath, it was so easy for her to make a vase…probably just depends on the time and experience you've got.

(10:09) Designer/craft, 40-50: I think I felt better with the computer program, because you can make big changes very quickly if it's spherical. If you want to make a lion, then I'm using clay.

(10:26) Craft practitioner, 30-40: There's something important about working on a screen and working with your hands at the same time rather than working on a screen which is flat:

even though you are imagining it as an object. An object inside a 2D flat screen, as opposed to…

(10:50) Facilitator: So what would you say is the main difference in that case? Is it the implication of your hands? Or?

(11:02) Craft practitioner, 30-40: It's easier to make an object out of something that's already an object, than it is to make an object on a computer screen which is essentially to the eyes something which is flat. You have to imagine it as a volume when it's not. Whereas this is already a volume, so you're working in a different way.

(11:20) Ceramist, 50-60: I'm also thinking about the fact that you quite enjoy the way things rip and the way the material smudges and you didn't know it could do that. That materiality, you don't get a chance to play about with it, you have to imagine what that would be like but fundamentally there is that thing that people will always like: fiddling about with stuff…mess. It's like primary school again. Yeah, so it's maybe two separate things; like when photography came and it didn't stop people wanting to paint and I think it will maybe make what people produce with their hands different. But certainly, flat things and perfect spheres are easier than they used to be, but that sort of form would be really difficult to model on the computer than it would in clay.

(12:30) Craft practitioner, 30-40: Something about imagination as well, because there's a lot of constraints with a computer that you don't really know about in terms of the program. Whereas with this the only constraint is, although there isn't really any other than gravity. Whereas you've got constraints in terms of the tools you're given on the computer and in the program itself.

(13:03) Facilitator: Well sometimes, there are people out there who use software to create or explore in a different way and some of them argue that it actually offers better opportunities for exploration. For instance, lets say you are working with a big stone and you are trying to carve something out and if you do something wrong there is no way back. Whereas the "control Z" combination in the computer allows us to go back. There's no undo service when you work with clay, with clay it's different you can do it again with another blob. But what is done is done.

(13:50) Designer/craft, 40-50: But you still work within the framework of the programme on the computer. You are still constrained by what the computer asks for in terms of the software itself. Whereas if you've got clay you can add wood to the clay or you can melt it down and dissolve it. You can not do anything outside of the program

(14:14) Ceramist, 50-60: I think you maybe right. You are determined by whatever the person or the people that thought the scope of the thing up in the first place.

(14:27) Facilitator: Normally a professional in any discipline; lets say graphic design or 3D modelling will never use just one software, just as you don't use only one too. You have your own tools and you have at least four of them. Each one is giving you different…

(14:48) Designer/craft, 40-50: Yeah but the tool; that tool isn't equivalent to the software

(14:53) Ceramist, 50-60: It's a lot cheaper!

(14:57) Facilitator: The software is free to use.

(14:59) Ceramist, 50-60: Yeah, yeah I mean this is totally revelatory the fact it is all open source and cheap and two years ago it would have been a different thing all together and in two years' time things are starting to even up. But I think with clay at one point you may want a wooden technique: a wooden print on the side of it. Or scratches so you end up going and grabbing another tool as you say you're going to use another piece of software. It's just at the moment there's not that many people who know what all the software is or how to use it.

(15:40) Facilitator: In the case of 3D printing we're still in an exploratory phase and most of the users are early adopters as they call it so we're not yet at that phase in which everyone knows about it. But I'm quite interested in knowing; why don't you think this is like the software. [holding up a pencil]

(16:01) Craft practitioner, 30-40: Because the intentionality of them is different, they are set up in different ways.

(16:20) Facilitator: Does anyone think that any software would be different to this [holding a pencil in his hand]?

(16:24) Designer/craft, 40-50: That's evolved. Tools have evolved.

(16:30) Craft practitioner, 40-50: I think a tool based software like Photoshop when you have all your tools, is kind of based on clay modelling but you haven't got the tools. Why don't you have a knife?

(16:43) Craft practitioner, 30-40: But you can do anything with tools, you can break this in half and make something entirely different from what the person who designed the tool would be expecting you to use it for. You could redesign a tool depending on what you needed it for, so you can snap it or do anything with it. Whereas the tools on the computer have a particular set of functions which you can not as a user rewrite because they are already there. You can not make the drawing taller on the computer.

(17:14) Designer/craft, 40-50: If they have comprehensive tools then you would be able to do anything if it was good enough software.

(17:20) Craft practitioner, 30-40: Yeah if the software was more intelligent of course.

(17:23) Facilitator: Well one thing is using the tools and another thing is modifying the tools. A craft master will make his/her own tools and actually if you look at blender people contribute to blender adding new tools and plug-ins that modify how the software behaves.

(17:47) Designer/craft, 40-50: It just depends on the level of your knowledge, but I actually find that digital software for modelling gives you more control, gives you the scale. You don't have to think that it might break in the end; you are in control of everything.

(18:16) Designer, 20-30: You know what's inside as well, so you can control how heavy it's going to be

(18:20) Craft practitioner, 30-40: But that control also removes chance and imagination and possibility. And that kind of experimentation. So you have control but you don't have the freedom of it.

(18:25) Ceramist, 50-60: You don't have the material fighting you back again.

(18:40) Designer, 20-30: I think that it's very dependent on the person, there are people who like control and there are people who like creativity.

(18:51) Ceramist, 50-60: I think it is just another tool. It's like we are all getting more skills than ever before. So it now means that people who can sculpt or can do woodwork at quite a high level can add this in to their portfolio of stuff. I can see blobs of potential but again sometimes it's just quicker and easier to go grab a bag of clay and do what you're really familiar with.

(19:31) Designer/craft, 40-50: My hands govern themselves, but on the computer I have to think about it. My hands will just do it and I can just think about something else, which is very nice, I can ponder what I'm having for tea. But if I'm on the computer I'm going to have to concentrate.

(19:52) Facilitator: I'm an industrial engineer by training. And when I think of making things my first reaction is to go into my engineering software and I'm so quick with that.

(20:11) Designer/craft, 40-50: That's true, so it depends on your expertise.

(20:14) Facilitator: I would never think of getting clay and doing it, unless you're making something that needs to be whole, or held, or handheld. Because then the best way of getting a feeling of it is modifying it with your hands. But in any case if I wanted to start prototyping I would go for cardboard. I would make something very nasty looking and get the dimensions lets model it and then I would go into the software.

(20:52) Designer, 20-30: For graphic design, they don't necessarily teach you anymore. So for me I study design but I don't do any manual stuff at all. If it is possible. So probably they were teaching you to make everything physically first and then take it into software, which is the opposite.

(23:03) Ceramist, 50-60: You might suddenly decide that digital work is not for you and you just want to get a bit of clay and make pots.

(23:13) Facilitator: I actually love clay and I did a residency as an industrial designer with a potter. We were supposed to be working with our engineering tools and creating designs for the guy and he said forget about that. I just spent everyday in the studio working with clay.

(23:40) Ceramist, 50-60: That's the thing, it's the fact it's not a polar thing. People like the fact they can not compete with it. But it's great to know new ways of doing stuff.

(25:17) Craft practitioner: I hope nothing breaks off it.

(25:20) Facilitator: We will see; it's supposed to dry itself.

(25:26) Craft practitioner: It's all those tiny details

(25:30) Facilitator: I mean they will probably get away a little bit, but I'll try to respect it.

(25:37) Craft practitioner: I don't believe it's going to survive. I really feel like a kid again today.

-End of recording.-

Focus group D

(0:08) Facilitator: I want you to think about this copy.

(0:34) Painting lecturer, over 60: This is so much lighter.

(0:47) Facilitator: so my research evolves around trying to exploit the ability of the printers that we all take for granted: replicability. So what is the difference between the original and the printed?

(1:25) Art lecturer, 50-60: Void spaces is obviously the first one. What's this material?

(1:34) Facilitator: That's air drying clay.

(1:49) Painting lecturer, over 60: What I like about it (the printing) is that it recreates the surface very nicely. The tactility of the surface, it reproduces that perfectly.

(2:03) Art lecturer, 50-60: Similar, but how is it scanned?

(2:05) Facilitator: 3D scanner.

(2:06) Painting lecturer, over 60: The tactility one experiences when one holds the object is related to the weight and the particular materials and those elements are lost. But in terms of looks it is amazingly accurate in terms of surface quality.

(2:38) Facilitator: As craft practitioners how would that make you feel?

(2:45) Painting lecturer, over 60: My work was called poetics of repetition, so I love anything you can reproduce and repeat so I'm on your side.

(2:59) Craft practitioner, 40-50: So a lot of creative practitioner in the fine arts like unique objects as a sole idea, but that tradition of repeating things

(3:11) Print maker, 40-50: In a way, you could say this is still a product of the clay. It couldn't happen without the clay; you've got to have this in order to make this. So in that sense it's still dependent on that and that being handmade. In some ways nothing is lost, something is gained in the reproduction and I sometimes do have a problem: we had an exhibition of cross portfolios between Norway, Edinburgh and Bristol university and from Bristol university there was a print that looked like a wood engraving from the distance but when you got up close you immediately knew it was a screen print. And it was just because they'd done an easy man's wood engraving, because to engrave the marks should have been a product of carving. But you realised they just mimicked that. I found that really disappointing.

(4:14) Craft practitioner, 40-50: Because you have a different sense of depth even though it's miniscule.

(4:28) Print maker, 40-50: There's a dependency on that (the 3D printer), that wasn't even in the screen print of the wood engraving. All you needed was the knowledge of what a wood engraving looked like but then they had not made a wood engraving. So I'm kind of ok about it. Normally we would have cast that in bronze.

(4:49) Craft practitioner, 40-50: And sculpture has always worked with reproduction and repetition and that's something that's been art-historically supressed. Since the renaissance artists have worked with copies.

(5:10) Facilitator: Yeah, production lines are not as new as we think. I was reading about the middle ages and how we've changed our perception of the influence of machinery. And one of the big criticisms is in all pottery when you have that master potter he sets the exercise and the apparatus will be doing tiny bits of it.

(5:42) Craft practitioner, 40-50: Yup, but then in art you always find until recently the hierarchy between art and crafts. So they would have disregarded pottery because that isn't art. But even in high art; people like Donatello or more recently in the 19th / 20th century is Hodan [undistinguishable name] who worked with copies.

(6:10) Facilitator: And they would have a set of people that would pay to record their paintings so it's not.

(6:16) Craft practitioner, 40-50: Yes, the workshop.

(6:19) Art lecturer, 50-60: It's about value though. I mean to be honest there is a snobbery in all of this. The limited edition, the unique pieces. For me the beauty of something is its mass produce ability: I see that's where the beauty is. Not necessarily in the individual piece. Which is quite funny because you have an artwork that you can now scan and reproduce in a different form for everybody to appreciate.

(6:43) Craft practitioner, 40-50: I suppose as mass production has grown we have an empathise on craft things that show the mark of the hand. And the interesting thing we're entering now: this idea that things can be manufactured and individualised in an individualised fashion. So in mass production is the production of the same.

(7:24) Print maker, 40-50: There's a parallel in book printing, maybe you would have one or two editions of something when it was first thought of and now you can upload your photos to the internet and have your own personalised, one off copy of a book. So it's the digital 3D version on parallel, but a bit further behind in terms of a mass producible thing. But from a purely personal point of view you can make a one-off and destroy the digital files and it can be considered a one-off. It's like a snake eating its own tail.

(8:06) Art lecturer, 50-60: Usefulness part of it, definition of art is useless. That's why I think it's strange for product designers to sit in here or any art college: because it's about the ease of manufacture for purpose. The thrust of these things for me is always about purpose. On the flip side is peoples seeming interest in the difference or collectability of things as based on not because they are all truly available because they're not available but people are drawn to them. Guys that collect yugioh cards; we've got a 9-year-old collecting cards. Fundamentally you can buy them and collect the whole series, to the extent that people's obsession is to the printing differences. Because you can get the whole set, the true collectors are now draw to the differences between the printing technique that are effectively errors. That's where the value is and it's always been about those differences.

(9:27) Print maker, 40-50: Interesting what you're saying, what you were implying is we've invented this thing but no one truly knows what it's for yet and what is it for apart from self replication? Just make yourself until we think of something to make out of it.

(9:55) Painting lecturer, over 60: So many useful things come out of that kind of thinking: something without a use. And you need to work without a product in mind.

(10:09) Print maker, 40-50: Printing in 2D came out of the idea that it was great to disseminate information and read stuff so that was born out of a need. But this (3D printing) is almost like we've got the technology but not the need.

(10:23) Facilitator: I've been doing some historical research on Guttenberg and the first thing that Guttenberg printed was a Bible.

(10:35) Print maker, 40-50: Yeah, propaganda.

(10:38) Art lecturer, 50-60: It's PR and marketing, it's always been that way. But it's about cost to start with, really high end at the start. So you've got expensive materials and outlays for the equipment, with opportunity to deliver cost effective products. Were you not saying about the medical industry? Is there not a link with the medical department making parts of anatomy based on scans? So it's obviously cost effective to do that, so there's a fundamental use for the product.

(11:24) Facilitator: The only thing is when you do that for human use, you have to go for really expensive materials anyway.

(11:32) Art lecturer, 50-60: So it's top loaded.

(11:33) Facilitator: Yeah, the difference is that now you can have an exact replica of the injury or hole that you need to fill. For instance, I know someone who needed surgery on the hip and they put inside of you a huge screw and then they just tweak it. And when they are done they cut. So just imagine you could scan the gap and the operation time would be shorter because you have the length already. And it will actually fill the twists, curves and geometry you need to adapt it to. So that's the breaking ground, it's not cost effective: it might be a little bit cheaper but it may not be too.

(12:21) Art lecturer, 50-60: But it will be better and fundamentally more useful and that's a key driver I think.

(12:29) Facilitator: It will be unique and that's the fun part of it, if it is about replicability and reproducing things we are seeing it's highest use is in unique things. Making or filling a cavity has been one of the first uses: which is quite unique.

(12:55) Craft practitioner, 40-50: The question is whether you are interested in how the technology, how artists, crafts people and designers think about it. And I think there will be slightly different empathise. Because with art I think for me is about making things visible that aren't: either we don't see them in this form yet OR it visualises things that haven't even been thought of.

(13:45) Print maker, 40-50: Perhaps you can visualise what you can not verbalise.

(13:52) Art lecturer, 50-60: But you just demonstrated there is an expressive quality using sculpturists for example. You're creating in clay virtually so expressive possibilities are all there in front of us. Surely the artist is there as they would originally with clay.

(14:08) Print maker, 40-50: This might open a way for a crafts person who makes unique objects to be involved in this production in a way they wouldn't have been before.

(14:19) Art lecturer, 50-60: Virtually instead of potter's wheel.

(14:20) Print maker, 40-50: Because before you would have said craft was entirely craft and very small editions.

14:29) Craft practitioner, 40-50: Pottery, you're thinking of pottery?

(14:30) Print maker, 40-50: Well I'm looking at this (the 3D printer) I'm thinking whether the person that makes this wants that to happen is a different thing.

(14:57) Craft practitioner, 40-50: It's very difficult to classify that particular object because it could either be quite a crudely made little vase or it could be; because in fine art there are people now who make deliberately crude objects; so it could filter into that as well. So I think somewhere it hinges on how the object is classified.

(15:29) Art lecturer, 50-60: It's an appalling object.

(15:44) Facilitator: The object was a test; she was involved in the experiment.

(15:58) Designer, 20-30: We were making a vase, we had 5 minutes and one of the girls made this. She has never clayed with her hands so it is obviously crude because she does not have the skill.

(16:24) Craft practitioner, 40-50: It could be part of a sculptural assemblage.

(16:46) Facilitator: So basically we did exercises with sculpturists and I asked them to do the same design with 3 different tools. And I was lookin at different things; one of them is the level of attachment with things, because then we did another exercise: allow 5 minutes for everyone to design something, print it and give it away and so on. Pass it on, we did the same with ceramics. IT was interesting to see how people were growing more attached to things with the clay.

(17:35) Print maker, 40-50: You mean they wouldn't pass it on?

(17:40) Designer, 20-30: The next person would be more considerate of the other persons work. In CAD I wasn't that bothered about other people's stuff, but in clay I felt like there was more effort put in. I wouldn't mess up something.

(17:59) Print maker, 40-50Because it was unique.

(18:01) Craft practitioner, 40-50: But could that be…kids who are now young, for them digital tools are like clay for us.

(18:20) Print maker, 40-50: There's no 'command z' for clay, if a piece falls off it. But with digital media you can undo, undo, undo.

(18:30) Art lecturer, 50-60: It also depends what your brief is and who your user group are. If we're being sensitive about other artist's work, that's an entirely different brief to 'make something better'. You've got this improve, change or keep it constant. Or sensitivity adapt it, it depends on what your brief was.

(19:02) Craft practitioner, 40-50: In these group things everybody has to build something together…Obviously the final outcome of what the group did together is more important than what the individual does. So you wouldn't feel so precious about it.

(19:18) Facilitator: That was my original thought, but then I was looking at people reacting differently and no one erased anything that the other created in clay. But there was a lot of erasing with the digital. And one of them said it was because of the time they had: 5 minutes. But that is something interesting about the brief you set: when you are making towards a specific end, it can really change your relation to it. Does it really influence your relation to the object?

(20:19) Art lecturer, 50-60: It depends.

(20:29) Craft practitioner, 40-50: We are kinetic beings and we function in 3 dimensions and when you're working on the screen, although there are kinetic elements you don't have that fully rounded…

(20:51) Painting lecturer, over 60: I always group artists in two groups; the painters who like to make a mark and immediately see a result and it's the final result and they get frustrated with anything that requires planning. Whereas printmakers, sculptures and video makers are used to making something in order to get something else. So you make something and you want that ability to edit. Even before we all went digital really: an etcher makes a plate before you get a print. There's always this matrix you can edit and I think this is a human difference and this (3D printer) continues with that. Maybe the unique makers can become a little bit detached so they saw their unique object as only planning for digital reproduction.

Because I would happily make something I knew I was going to throw away at the end, that's what I do all the time. But to get a painter to do that is more difficult, but they can be taught by recording their own development. We use that as a way of trying to not let them be scared of destroying a painting: you're just learning so carry on.

(22:25) Art lecturer, 50-60: The other obvious one for me is the connectivity with materials. We're completely dissociated from the material, both in the constructive and the visualisation, but also in the outputs stage. So if you're making clay stuff or painting: it's the dissociation of that with the hands on experience which is what this is about.

(22:50) Another English Lady: As someone who doesn't do things in 3D or doesn't do mark making, I feel ferociously protective of my digital work. If I've spent three weeks' type setting a book, it is my baby and I do feel very protective of that. It's not just the digital we're looking at, it's the investment in the work. The age you are is important: it's about what your tools are, like someone came and took your car apart in the middle of the street: you'd be really, really pissed off.

(23:38) Painting lecturer, over 60: There's hands on in digital, just because it's not hands on like that doesn't mean it isn't craft. It has long been recognised and written about. But it still isn't seen as an art form. One thing I have seen teaching the digital elective to painters; whether it's because we get painters who aren't these digital children but they are young enough to be and yet they are not. The texting digital and they can just about type with two fingers.

(24:24) Craft practitioner, 40-50: People who are digitally inclined don't do painting.

(24:35) Painting lecturer, over 60: But they are still the biggest group in fine art.

(24:38) Craft practitioner, 40-50: I think there is also a counter reaction that people go more towards hands on stuff.

(24:45) Print maker, 40-50: I think that's right, but I had a very clear example of that because I've been working on all the degree show stuff and I had submissions from someone in fine art. And they couldn't use the crop tool properly to get the corners, so I did it for them. I was really astounded it couldn't be done, I reckon my 9-year-old could do it.

(25:27) Painting lecturer, over 60: We fear we will lose the human beings who like making stuff, but actually we keep bearing them. Which I am grateful for and they're not technophobes as such but they do come here to do other things. Most of my students are still making wood cuts.

(25:44) Print maker, 40-50: Quite rightly.

(25:47) Facilitator: 3D printing has arrived in the adequate moment, because there are a lot of people claiming back the materiality of our work. One of the questions I ask myself sometimes is 'are we that digital?' and I don't think we are.

(26:09) Design student: It depends on what you perceive as being digital.

(26:12) Facilitator: I don't think there's that divide, that strong divide as you were saying. I think people get very protective of digital files as well as non-digital creations. If we think of the processes we've been seeing today as a tool, as a creative tool how would it change the perception of the discussion? So normally we use tools to design things and we grow more attached or not depending on your objective, set of tools, how removed are you from the material?

(26:55) Craft practitioner, 40-50: How long you've been using it, because at a certain point technology becomes like second nature. And that's when it's best because it becomes an extension.

(27:12) Facilitator: So it doesn't need to be digital or non-digital. That's one of things I'm trying to address: does it make a difference they use a 3D printer?

(27:23) Print maker, 40-50: I suppose there's a parallel in all these things like inter-media/ art-filmmakers because that's gone almost completely digital now nobody questions it and I suppose there's a parallel coming up.

(27:38) Art lecturer, 40-50: They love the overhead projector.

(27:43) Print maker, 40-50: But that's what you're saying, just because it's fallen off the radar it's back in again.

(27:50) Art lecturer, 40-50: They love the obsolete technologies because it is different and they still want to be taught so.

(27:58) Designer, 20-30: And then you think about digital photography as well. When the cameras become digital everyone moves back to analogue. That might just happen with 3D printing as well.

(28:13) Art lecturer, 40-50: I mean professionals are really the ones embracing digital, although they might also maintain analogue. Analogue cameras are now being sold in Urban Outfitters in boxes like plastic toys. And young people are showing them off 'look at this, it does this' and you're like 'yes that's a camera'.

(28:36) Print maker, 40-50: In a record shop someone came in and said 'look you can have all your collection on vinyl' and we went 'we've already got it on vinyl'.

(28:44) Craft practitioner, 40-50: There was an article a couple of weeks ago about exactly that. Maybe it's a minority group, but people who go for vinyl, it's a big business, it's not cheap and they go for a lot because the sound is better.

(29:13) Print maker, 40-50: They're re-mastering them all.

(29:26) Art lecturer, 50-60: Old school audio files are archival and linked to their past and also the collectors.

(29:33) Craft practitioner, 40-50: Yeah but some of them are young people.

(29:37) Art lecturer, 50-60: Totally... DJs! It's a hands on experience.

(29:46) Facilitator: But it's the weight as well. For example, my father loves listening to music, but he doesn't do it out of the car. So last time I did an experiment: I grab a bunch of vinyl's from a member of the family and I said 'lets play some music' and he loved it. After that every afternoon while I was on holiday he was actually taking them, sitting down and listening to them.

(30:22) Print maker, 40-50: It makes a difference; you have to walk to the machine to put it on. You make the time to listen.

(30:27) Facilitator: But he would never do that with CDs. He has a big collection of CDs and he's not doing it.

(30:33) Print maker, 40-50: I thought you were going to say he set up his LP player in the back of his car.

(30:47) Designer, 20-30: Young people who are listening to them, the one big example is they want to be different and show they're not like the mainstream. There is a psychological phenomenon when you're over sixteen and under twenty-five: you want to be different just because everyone else is the same.

(31:19) Facilitator: Supposedly because he's trying to be a hipster now. It's not that different.

(31:26) Craft practitioner, 40-50: There are two bikes that don't have any gears.

(31:43) Facilitator: Just to conclude, 3D printers contain some parts of CNC routers: to oversimplify 2D printers. And I thought that was quite an interesting metaphor concerning what we are talking about. There's a book called Future Shock by Toffler, and basically he says the future is coming too quick. And that's why sometimes people get back to the previous technology or the obsolete and he poses all sorts of questions about why that is happening. But one of the things I'm looking at is, how we understand the technology. For instance, if we look at a 3D printer as a 2D printer with a vertical axis, it will actually simplify how we see it as a technology.

(33:01) Art lecturer, 50-60: Back to the graph thing, it's about degrees of change. And I think one of the dangerous errors that we feel people are falling into these days, is the rapidity of change. The change is happening exponentially quicker, so I think that lends itself to the feeling of insecurity. And you see it on a day-to-day basis, everything is an upgrade. SO there's no stability platform for you to firmly ground yourself on. So I think analogue technology has currently got lots of fans but you can see the linear growth and we hang onto it.

(33:47) Print maker, 40-50: Difficult to become skilled if you're constantly holding onto it.

(33:52) Art lecturer, 50-60: It's unsettling to your experience and to your knowledge base. And that's where professions lie in.

(33:59) Painting lecturer, over 60: We all have software I think we don't upgrade, because we like the one we're using and it does what we require it to do. Also it can become about…I suppose the thing of invention is the software itself, as opposed to the purpose of the software. And that's really where we would like progress to be, maybe the purpose so the software is put in usage to which something is put. Unless that develops with the upgrades to the software itself.

(34:29) Facilitator: It's quite interesting, three weeks ago there was millions of dollars thrown at Microsoft to get working with Microsoft XP or Windows XP. Basically because everyone is using XP and office. They were stopping the support of Microsoft Windows XP. Which if you think of it is probably one of the most long lived. It works like a charm.

(35:01) Designer, 20-30: One of the most popular.

(35:10) Facilitator: So that's quite an interesting example of how we linger on what we know.

(35:16) Craft practitioner, 40-50: I mean I didn't want to contradict anything that's been said. But I think there's also a common sense that technology is progressive: it stands for progress and yet there is a hyperbolic view of technology. I think culturally a lot. But by the same token, I think people have talked about technology in terms of remediation: that they remediate what is already there. We tend to think of technology, the way it's presented in mass media, is totally new.

(36:26) Painting lecturer, over 60: I mean Photoshop itself is the best example because it's entirely developed to do everything that was done without it. But reproduce it.

(36:35) Art lecturer, 50-60: With ease and access for all.

(36:37) Painting lecturer, over 60: Except there isn't ease, because you have to craft a Photoshop file and it will take you hours. So in a sense it's a myth and we still haven't discovered what it can do.

(36:51) Facilitator: Drinking from the previous skill set, if it is well designed you should be able to transfer your skill or knowledge based on your skills to use that tool.

(37:06) Designer, 20-30: But what Photoshop does, it doesn't require the space you would need for it.

(37:13) Painting lecturer, over 60: No, it doesn't require stuff, you can cut and paste without glue, scissor and a mess.

(37:19) Designer, 20-30: So you don't have to spend any money on additional resources.

(37:26) Facilitator: You pay for the software, the thing about the software; everyone that comes to the workshop, well not everyone. But the ones that learn about it, I am using open source software for most of my things.

(37:37) Print maker, 40-50: But there's parallels for all the Adobe software.

(37:39) Facilitator: They're parallels but they are not easy to use.

(37:43) Print maker, 40-50: They're clunky-er.

(37:44) Facilitator: Because they are compared to the university's. When you come to university you learn Photoshop or Inventor, which was my case. When you come out of university, you try to get it and think 'that's not going to happen, I would rather hack Photoshop or hack Illustrator or pay and find a professional'.

(38:02) Designer, 20-30: But on the other side, they made it so accessible and almost really cheap. I mean to be honest, I was hacking it for years before but now when they introduce the creative cloud. But I don't mind paying £15 per month, it's not much, I spend that amount on coffee. I pay gladly! But if I would have to buy a licence I would probably just hack it.

(38:36) Art lecturer, 50-60: Back in the old days, I mean I've colour printed by hand and what an enormously costly and time consuming business that was. And with none of the positive outcomes that I think digital technology offers to the final result, to be honest. Slightly different view about exhibitions; quality printing but that's another thing. But in terms of it's purpose; the idea of it being able to produce results that are part of a service, it's faultless. It's hard to learn and time consuming but it depends what your objectives are. It's a tool.

(39:26) Craft practitioner, 40-50: Never throw anything away.

(39:31) Art lecturer, 50-60: I threw away my old enlargers and I'm glad to be rid of them.

(39:37) Print maker, 40-50: But there's other people who would do something amazing with them.

(39:44) Art lecturer, 50-60: Going back to the cyclical nature again they wouldn't be going that much differently to what was happening previously.

(39:52) Painting lecturer, over 60: No, we just do it differently, more quickly and store it differently but it's not different. What men want to do with it is still very similar.

Focus group E

(0:01) Design professional, 40-50: Seeing the bones being made, I had quite an understanding of what it could do, the effect it could create. So I came with that knowledge but it's been really good to see the software, see the use and take me through that. That was really useful.

(0:26) Art lecturer, 50-60: Yeah, it's tricky. I brought a lot of information but I'm going away with quite a different set of information. Now I need to figure out, how can I get something from that.

(0:38) Facilitator: So if you come to an AHA moment, it would be nice to hear about it when you process the information. Yeah, I actually realised some of the projects I've been doing, an AHA moment happens when you are very far down the line of designing. I mean for us when we were doing those things, we've been working together for a year maybe.

(1:18) Design student, 20-30: For me before I come, I think it can be used in the medical area. Like we can mimic the bones or organs to replace ours or the patient. But now I think it can represent everything in the physical world. So you can use it in the film industry for example, to do the fantasy movies because we have the properties, we can design with the 3D software almost everything I think. Yeah, it's amazing.

(1:53) Facilitator: And you? Has anything changed? So you had an idea and now you have a clearer view?

(2:02) Artist, 20-30: I think because I've done this before with you, it's different but what's really interesting is meeting other people and seeing other creative practitioners and what others have done. And would like to do with 3D printing. And I've had that conversation about: what I would like to use it for and how it can be applied. So not just how I've gone 'this is how I would like and this is how I've read online people are applying it' but what people who haven't seen it before have come to say 'oh this is how I was thinking of applying it'

(2:38) Art lecturer, 50-60: Yeah I second that, it's how the people in the workshop respond.

(2:49) Facilitator: Right so, what do you think people are using 3D printing for? You've seen Thingiverse, what do you think is the general use? I'm not talking about experts on the medical field. Have you gained any feeling of what people are doing?

(3:41) Artist, 20-30: I think there's a huge variant just between what the books say on art, technology and 3D printing methods. So when you look at Thingiverse, the comparison between the two is quite stark. Thingiverse is like 'oh, I printed a ukulele and a recorder' there's a kind of techy, geeky, fun, big child. What was the demographic? The men in America, between thirty and forty and they've got loads of money and they're doing these things. And there a silliness about Thingiverse, which when you look: the books are more professional and there does seem to be a stark contrast between them. The Thingiverse seems to be more like kid's rattles, but then there's the chainmail and the moving figures and things like that which would obviously be perfect for animation. So there is a cross-over but overall it's quite one and then the other. The 3D mapping thing with the guy from glass, that's one way of looking at it, but you don't see that kind of stuff on Thingiverse so much. But maybe one day it's going to cross-over.

(5:13) Facilitator: Basically what I'm doing is trying to find that crossover. So I'm bringing people that are professional makers or creative professionals and I'm becoming instrumental in how to diverse the technology in order to bend it towards your commitment. It's quite funny what you said, because you are using textile and you're bending textiles in order to make something quite different that is not what most people are doing. That's what I'm trying to do with 3D printing. Throughout the activities today have you perceived any limitation to 3D printing or any errors that will prevent you from embracing it.

(6:16) Design student, 20-30: I can not think of any reason, it's so convenient I think once the technology develops into a certain level, it might sweep the whole manufacturing industry. We may in the future just build our own things, like chairs or table. We don't even want to buy it because we can design it by ourselves and print it out at home.

(6:41) Facilitator: Yeah, it's what they're saying about 3D printing, I don't know if I completely agree with that, but yes it could happen. And you?

(6:51) Art lecturer, 50-60: For me, it's just using the software, I'm very envious of you already having those skills, it just puts you miles ahead immediately. That's just my laziness: lacking a digital commitment. I think you bring something else, if you can not attempt to do the same thing in a different way, so it's good to see that you could come with an image and still get something that can become a creative piece. I like the idea of using a part of a process, not necessarily the entire thing.

(7:30) Facilitator: So, for instance one of the discussions that we had in previous workshops, was about how limiting software can be. There were people saying that the two processes: the handmade clay models and the digital versions of it/digital creations they were making: they were not relating to the in the same way. They were saying the clay tools they were using were not as limiting as the software we were using. Would you agree on that?

(8:03) Artist, 20-30: I think it might be the kind of person that you are, though I would say quite often when I'm trying to do something on the computer I think 'I could probably draw this' or 'if I had some clay...' You know what it is, but it depends because with some people that's not how they interact with the world. Sometimes computers just make sense to people, more than other people. Or you've used it more. If you are coming from a place of 'I make things with my hands' and 'I spend a lot of time drawing, modeling or building' then that would make more sense. To me it would make more sense, I'd be able to build you a box out of clay faster than on the computer: because that's what I do. But if you weren't a creative practitioner or you did digital media and you're very computer savvy and that's your profession. Then you might find the software a lot easier to control.

(9:16) Facilitator: There is that: as well as how we see software depending on how familiar you are with it. For instance, there was someone who said 'software is quite limiting and it doesn't allow you to for instance compare a wooden stick, used for modelling clay with illustrator. And basically because he saw more flexibility in the wooden stick than in illustrator. But my counter argument is that when you're designing you don't work in just one software. And don't use just one tool. So that's where I see 3D printers becoming quite interesting within other practices for generating media or for making something inter-media.

I presume you don't just get to use one tool or one process in your creative practice? I want to ask you all something else, relating to this piece. So I give each person who comes to the workshop 5 minutes to create a model and then that model is passed down the room to the following person and that person works another 5 minutes on it. So it was quite funny to see how people were deleting things that other people had done or modifying a lot. But then I did the same experiment with clay and no one dared to modify what others created and that was quite an interesting difference.

(11:19) Facilitator: I really like this example, I created this hoop and then passed it along and the next person just dropped it and put it upside down, and the other girl turned around and said 'What?' There was a lot of criticism in that group, they were swapping conversations all the time. And they were quite happy when this was turning into a shrine but the person handling it at the end added this thing, which they thought was a butt coming out of the shrine. It was quite insulting for the original one who started it. Why do you think they'll feel more attached or precocious about respecting what another has done in clay rather than in a digital model?

(12:28) Design student, 20-30: I think the reason maybe, if it's the handmade stuff it's not easy to consult what I've done to that thing, because with the computer I can undo or redo: I can see the effect. If I don't like it, I just cancel it. So you can make changes easily, but with this once you've made a shape like that: you just cannot redo or undo it into a former shape. So I think people don't like to change it.

(13:02) Facilitator: Do you agree with that?

(13:07) Art lecturer, 50-60: I think it also comes back to that idea of being a thing and traditionally we thought an original piece of artwork had value: whether it's a good thing or not. A child's work you wouldn't necessarily improve or change It because it has a spirit or a character from that person.

(13:28) Facilitator: But the digital file will have the same properties.

(13:31) Design student, 20-30: Yes, I can even duplicate it and make my own changes. Also keep the original one.

(13:38) Facilitator: Well, with clay you could do the same, you can undo, you can take the tool or add more clay and get it back to the original.

(13:45) Design student, 20-30: It's not that easy or completely the same.

(13:49) Facilitator: So it's about the skills you have to actually undo.

(13:58) Artist, 20-30: Especially if you were using tinker CAD it's quite… obviously sculpture is more relatable. But if you were passing tinker CAD around to everybody it's like 'these are the set shapes and you can put the measurements on'. It's a lot quicker to duplicate than someone's personal hand touch on the clay. Even if you wanted to, you don't even have the same fingerprints as that person.

(14:37) Facilitator: So it's about the perception and the physical relation with the material in itself.

(14:46) Artist, 20-30: I think we don't see what is digital as real. When you print it out that kind of crosses that boundary. But something someone has touched, created and passed on is not quite the same as something that's not real, a portrayal of something

(15:10) Design student, 20-30: Yes, it's like something in another world. I agree with that. If you just pull off the leg of my little monster, I will probably go 'Ouch! Why did you do that?' Because it has become real.

(15:27) Artist, 20-30: There's a really interesting documentary on second life which basically deals with people's perception of the digital being real.

(15:37) Facilitator: Americans are selling things there, you buy them online for your avatar and at the same time get the real copy for yourself.

(15:52) Design student, 20-30: Tiny, tiny clothes and people.

(15:59) Facilitator: So do you think time will influence that perception of how you would respect something?

(16:11) Artist, 20-30: I think for both, if someone has spent a lot of time working on something on the computer. But it is that idea that you could very easily go back. But you can obviously save it and you can not go back. There is a point at which you can not 'ctrl z' anymore. But if someone had spent 20 minutes on the computer and 20 minutes on the thing (clay)…yes but for both.

(15:59) Facilitator: That's quite interesting because as soon as they'd finished that and I asked them this very same question. They said 'wow, we spent more time with clay' and I said no it's only been 5 minutes and they were all shocked. I don't know if it was that they were more immersed, because that might be more immersive if you get your hands in, the smell of the clay. It's probably something to do with the medium anyway.

(18:00) Facilitator: So [Participant name: Artist] at the beginning didn't have any modelling experience and now she's doing quite interesting stuff.

(18:07) Artist, 20-30: I'm quite fluent in Photoshop and illustrator beforehand and I use lots of laser cutting software. And really it's harder to do it in the 3D and it's still taking me a while to think in 3D, especially as I spend a lot of time screen-printing in 2D. But, through a collaboration everything is becoming clearer and easier to understand.

(18:20) Facilitator: what about others? How would you see using this as a part of a collaboration?

(18:29) Art lecturer, 50-60: Yeah, that would make sense. I suppose, that would open it for me. And confront my laziness about the digital. IF I can find something to say with this, I am happy to explore it in a collaboration.

(19:01) Design professional, 40-50: I have already done stuff like this, and even if I don't have the technical skills, collaborating always brings new things to explore. Makes, working with all this easier.

Focus group G: Talking While Making+ brief discussion. 1.20 minutes.

(1:43) Art student: Does is have to be something? Since someone else is going to work on it anyway.

(1:50) Facilitator: Why wouldn't you make something you want to make?

(2:00) Art student: What if you don't know what to make.

(2:03) Facilitator: Do you want me to say something you could make? Ok, we've done flower pots before.

(2:23) Art student B: Oh I've got an idea actually.

(2:30) Facilitator: Sam is here, that's good we can make five.

(5:14) Facilitator: You are workshop D and G5…we design something for 5 minutes and whenever the rain goes off we'll close it and jump to the following number.

(11:14) Facilitator: Alright now we jump onto the following number. This time I take on G1, you take G2, you G3…

(12:14) Design student A, 20-30: So should I just work on the current design?

(12:16) Facilitator: You can do anything you want with it, you can delete bits, you can just think about how the other person might feel. Oh what can I do with this?

(12:38) Design student A, 20-30: You can do anything!

(17:15) Facilitator: Alright that's it. This time I take on G5, you'll be on G1, you G2…

(25:14) Facilitator: Ok that's it. Ok you take G5, you'll be on G1, you G2…Alright go!

(31:00) Facilitator: Ok that's it. So last round: G1, G2, G3, G4, G5…what the hell is that? That's nice.

(37:20) Facilitator: So how did it feel to be editing someone else's work.

(37:24) Design student B, 20-30: It's great, you start from an idea rather than with cover with others: it creates other ideas.

(37:40) Facilitator: Yeah, takes it to weird places. But on the other hand you wanted to create something specific. What happened to it?

(37:57) Art student: I don't know; I can not see it.

(38:00) Facilitator: Where did you start?

(38:03) Art student: I was four.

(38:16) Facilitator: Yeah, that was cool originally. Probably if I click on it, it will dissolve. I presume you did the bits that looked like a chair on a table.

(38:54) Art student: Yeah, I did the chair looking thing. I guess it's just evolved into a car with chicken arms.

(39:04) Facilitator: Yeah, it was nice to see, because at some point it was a very nice chair on a table.

(39:12) Art student: Now it's transformed!

(39:14) Facilitator: But then I modified it, to see what I could change it into.

(39:40) Facilitator: So what do you think of it? What do you think of your original creation?

(39:44) Art student: It's still there because you can still sit on it. It's cool.

(40:03) Facilitator: So I ask people to vote for the best one: for the one they prefer and try to get it printed at one point. Who started this?

(40:36) Animation lecturer, 30-40: I think that one was mine.

(40:38) Facilitator: And what did it start out at the beginning?

(40:40) Animation lecturer, 30-40: Penguin

(40:50) Art student: I put the rabbit ears on top. And I gave it a heart as well.

(40:55) Design student A, 20-30: The eyes were really big and jumping out: so I deleted them and made them smaller and friendlier looking.

(41:12) Design student B, 20-30: I added two fingers but they were not objects. And I gave it legs.

(41:40) Facilitator: This one will be difficult to print. So I started this one, now it only has one leg.

(42:44) Art student,20-30: That one's really funny! It's like a Pokémon.

(43:00) Facilitator: Oh that was the bird accommodation, it started from an egg. that transformed into an accommodation with the stars. And now a Picasso with a transgender sense to it!

(43:29) Facilitator: G5 has gone all nuts. You started this one what did you try to do?

(43:38) Animation lecturer, 30-40: Just a ring with a butterfly

(44:06) Animation lecturer, 30-40: And turned it into a fairy,

(44:12) Facilitator: And who made it into the belt?

(44:14) Art student: I just added the star, the legs and changed the hair a bit.

(44:40) Facilitator: Which is your favourite? Hands up for G4, G3…G1 is the winner.

46:24) Facilitator: So, I like doing this because you are starting to develop a better understanding of what you can do with tinker CAD. It's quite nice to actually analyse what would be the possible forms of those 3D models if we wanted to print them. If we go to the one we want to print, that is going to be very difficult to print, there's going to be a lot of support material which will mean whenever you are taking away support material you might break it. So thin protruding parts are not very good. Again it depends on the size, if I print it huge it might be ok, but if I print it small like I'm going to do; it might not be very good. Oh it's hollow…it will be hard to print. But here you can guarantee it will be printing. But one of the strong points of 3D printing, you can build anything. You can build a ball inside of any other geometry and there is no industrial process that can allow us to do this.

Scalability… This bone has been produced with a CT scanner…this is another bone the backbone of the head of a baby. This is a good example of how support material might influence the geometry.

Thingiverse is quite well known all around the world, because you can show models and content, upload it, use it and modify it. If you upload this model on Thingiverse it might come around in 5 months completely changed. And that's one of the really interesting things 3D printing is doing: changing the face of physical interactions. You can just share physical objects like that, across the world. Do you think it's going to change collaborations somehow?

(51:30) Design student, 20-30: Yeah, maybe you'll get 3D printed food.

(51:37) Facilitator: Yeah, there are many things like that. Someone has been working on 3D printing steak or meat which is basically using protein. You've probably seen or heard about people 3D printing ears so it's almost the same process apparently. The 3D printer has been used to make it in a specific way. So you as a product designer, how do you think you will use these kind of tools.

(52:30) Art student,20-30: It's good for people in different countries, instead of flying in to come together, they can do their model, upload it onto the database and someone else can use it as well. And they can edit it so they both have the same thing and print it in different places.

(53:00) Facilitator: Do you think it will be useful? What If you take it home? Will they see any use for this at home?

(53:07) Art student,20-30: Yeah? The only thing I am worried about is the expenses right now. Because they are really expensive are they not?

(53:19) Facilitator: Three hundred dollars…five hundred dollars plus taxes (since its imported from America). That one is £1200 or it was when I bought it but now it's cheaper…And the plastic is super cheap, I have not finished any spools yet and you can print and print and print.

(54:04) Art student,20-30: I'm just wondering if you had it at home, would you have to use it all the time? Would you want to use it all the time? Depends how much you consume things, can it be recycled: re-melted down again and reused?

(54:23) Facilitator: Yeah, it can be reused, but there's a lot of people working on that but it's not there yet. And you? Do you see any use in your practice?

(54:43) Animation lecturer, 30-40: Yes, well for animation it's already been proven that it works to make a model or a bit of a model. Like we're just printing the face and the rest of it's made of something else.

(54:56) Facilitator: At home?

(54:58) Animation lecturer, 30-40: Um I don't know. I'm waiting for the day you can download a car and print it.

(55:14) Facilitator: Well we are maybe not that far, because they are starting to be able to print very low level electronic 3D prints. So whenever the time comes in which we can combine different things at the same time, it might actually work out that we can make working electrical things. What do you think?

(55:48) Design student B, 20-30: Same as her, it could probably be a model. I was thinking of some toys; like Legos because you can reproduce a lot.

(56:02) Facilitator: Yeah there's actually a really nice project, called the universal toy connector. What do you think about your practice?

(56:24) Design student A, 20-30: For interior? As you said it allows you to make models, for example design a chair or piece of furniture.

(56:39) Facilitator: I presume you could be mocking up setups of different things as well.

(56:60) Design student A, 20-30: I don't really know because the size of the printer is limiting. If you can imagine that being as big as you can, imagine all the possibilities.

(57:07) Facilitator: Well the good thing about this kind of setup, is that you can expand in an axis. So this standard piece, you can find it in a two metres long piece. So you will have a very tall vertical axis. It might not be very stable but it is there: you can modify it to make it stronger. That is the advantage of open source machines.

(57:40) Design student A, 20-30: Are you considering the current technology or future? If you imagine the printer can print fast enough and big enough…it will sort problems of transport and quantities.

(58:25) Facilitator: There is a very famous guy, he uses his 3D printer for repairing his cars. It's so cheap compared to getting pieces from the manufacturer that may not even exist anymore. So he has a really nice scanner, scans pieces and remakes them with 3D printers.

(59:00) Facilitator: So there are a couple of projects, I'm going to open them there…you can 3D print with whatever you put in it: chocolate, cakes. Resin, molten plastic. I've been doing experiments with clay and glass powders. What is funny is they envisage the future to be something like this: providing cakes for the mother.

…They can make ibuprofen simply by adding proteins at the right moment. Would you trust that? Universal toy connector…it's designed by a parent who was struggling to get the right Lego kits for his kids. Ok I'm going to give you some time to create what you want.

(1:02:01) Facilitator: Ok, so how do you perceive this a s part of a tool set, lets say, how do you see this digital tools as part of your process.

(1:02.20) Animation lecturer, 30-40: Um I don't really see a great deal between one tool and the other [refereeing to digital design software and pointing at clay models on the table] . Although, I prefer analogue processes I focus on the outcome and how it can be produced in the best possible way. In animation, we are story driven and that is what drives the process from my point of view.

(1:03:13) Design student B, 20-30: for me there is no difference at all, it is all part of my way of working since I do a lot of prototyping with my hands and cardboard, a lot.

(1:04:11) Facilitator: That is very interesting, what about the rest? DO you see a distance between the digital and the analogue in your practice?

(1:04:46) Design student A, 20-30: I am still seeing the limitations with scale in this case, but I don't see such a thing as analogue vs digital, I frequently use digital for planning and visualization… but in the end [referring to degree show] your models need to be there. So for me is tangled, there is no one without the other.

(1:05:15) Art student,20-30: is it that important? I am post digital [jokingly] Labels are there to be explored and broken. Finding a language or… way out for your dialogue, the means, digital or analogue are not as important. I think most of us [referring to the group in the workshop] share the idea that is just a matter of integrating technology with other tools.

[there was a general sense of consensus, but unfortunately the conversation was brought to an abrupt end by caterers delivering food]

Focus group J

Workshop J

(2:38) Facilitator: What are your impressions of what you've seen today?

(2:43) Photography lecturer, 50-60: Personally I have to take stock, it's not what I expected. I thought you'd just put something in at one end and it would come out of other. And the machinery itself, I find fascinating, it's this combination of extremely high technology and mechano. In terms of what I do, the main benefit for me is keeping up with this on behalf of students and their interests. People see 3D printing as such an abstract thing. And now it has become more tangible for me. I think at some point something might come into my head that would suit this. Right now it's too fresh.

(3:53) Painting lecturer, over 60: If it's about making an object and what values that object holds when you've made it: is it any less or any more? Because kids in five years' time will be doing this, it's still relatively new. There will be a museum somewhere with the first 3D printed object but once the first one is there, what would you collect? What is the thing? Because that's where the art, design, quality and meaning embedded in that object has to come in. You can do anything and make anything you want, but why?

(4:57) Photography lecturer, 50-60: See photography is not dissimilar in a way, it's made by a machine. For example, something I always tell my students is: it's the context that it's shown in. These old pictures are the only ones I carry of my son and it was done with a passport machine. Without saying it is a brilliant piece of art, it is in the way it was scaled and presented it's quite uncanny. Yet as a mechanical, there is an empty wonder to that which says 'that's what it's like to be young'. It's the business of context and as photographer we're used to that in a way. You've got this thing anybody could do, but with the right scale, framing and text it becomes something else. I think there are opportunities here in that respect.

(6:26) Painting lecturer, over 60: It's the idea of the object being some form of transition. Things have always been manufactured, saying earlier 'the great exhibition of 1800s companies were showing off what they could do. They made some bloody horrible things but that wasn't the point, it was that you could integrate joints etc. But when they got past that, they had the arts and crafts movement and it takes that to start it off. Like what happens to painting when photography takes over. The object in a bigger sense is a generic thing, being in transition from one form of manufacture (whether that is by hand) and into another thing. And while these machines can eventually print with anything, it still has the feeling of a potato peeler. The bigger the machine: the finer the pixels. But one of the intrigues for us is seeing how it is made, the better it gets the further away it becomes.

(8:09) Photography lecturer, 50-60: You could foresee the business of RGB, you can imagine RGB heads going in there and this translating into those realities.

(8:33) Painting lecturer, over 60: You would just press play and your cartridges would change the heads quickly.

(8:47) Photography lecturer, 50-60: The further down that route you go begs the question even more.

(8:56) Painting lecturer, over 60: Once it gets too good. Only when technology becomes redundant will artists start to play with it.

(9:32) Art lecturer, 40-50: It seems to me it's got the aesthetic of the computer screen, a commodore computer screen. Which now people who are digitally minded want their websites to look like they were designed on a commodore because that's cool for them and quite difficult to do.

(9:53) Painting lecturer, over 60: It’s reverse technology, it’s got to be just crap enough.

(10:00) Photography lecturer, 50-60: I think it’s value and worth in terms of Product Design is just mind blowing, in a generic sense. Within the art context it’s a bit less certain, there’s a kind of weakness. But certain students could really run with this, fresh minds, all kinds of things could come from this.

(10:32) Painting lecturer, over 60: It’s whether you could use it as a catalyst for something else or is it the end use?

(10:41) Photography lecturer, 50-60: It’s not.

(10:46) Painting lecturer, over 60: Let’s use your one as an example. If you took the thing that you make now and then you photograph it, but then you print it. Remember the very first computer programs for 3D stuff? William Latham? Basically he had designed a program for sculpture and it had nine buttons, you could do the Jacometti (Ignacio Jacometti) buttons. But at the end of the day he was still looking at his computer screen, which was about that size and like most of the stuff NASA would have used at that time. And he was sitting with a hammer and chisel trying to copy it, so it was just an elaborate sketchbook. Must have been about 27 years ago, because on screen it looked amazing; really beautiful and ornate, shell-like structures. But in the end of the day he still had to put his hand to page and use charcoal.

(12:06) Photography lecturer, 50-60: How does this differ from what Tony Cragg does?

(12:14) Painting lecturer, over 60: It doesn’t really.

(12:24) Art lecturer, 40-50: He works in Germany now because of the technology and because they have the ability to make anything.

(12:33) Painting lecturer, over 60: You have to watch with these things.

(12:36) Photography lecturer, 50-60: These objects sell for huge amounts of money. I went to the show in Belford Road and it was just full of computer generated things in bronze.

(12:52) Painting lecturer, over 60: It starts in a computer as a manipulated form.

(13:08) Art lecturer, 40-50: He’s been doing those since I saw them in Liverpool about 10 years ago.

(13:17) Photography lecturer, 50-60: He has a factory where he just churns it out. I don’t know how you feel about that as a sculptor?

(13:22) Art lecturer, 40-50: I still think he does enough interesting stuff with enough variety. But then again I suppose once you look at it, he does make 200 very similar things and then move on, well his assistants do it. At that kind of scale, it doesn’t seem very much like what I have to do.

(13:42) Photography lecturer, 50-60: Some of these will be unique objects. They’re definitely made using this kind of technology.

(13:50) Painting lecturer, over 60: But the Gormley pieces with the wire and the Scottish man: David Mac, he uses the computer to make the shape. And it’s like measuring depth, and then he reverses that to get his spikes out. So therefore what was a very complex thing: is a program that allows you to do it. It looks incredibly complex. Tony Cragg with his heads, once you’ve seen it once you’re kind of, ok I get that. I think they’re great things.

(14:50) Art lecturer, 40-50: Tony Cragg is still inventive enough that it’s interesting

(14:56) Painting lecturer, over 60: Interestingly he still hand draws. His watercolors are real one shot things, there’s no mistakes and no rubbing out. And yet what he makes is computer generated. But I think when you are hand drawing you can imagine what it will be like on the screen. He still needs that.

(15:23) Photography lecturer, 50-60: Yeah, but he’s a big president, I mean we’re talking about how this relates to the unique pieces of sculpture done.

(15:32) Painting lecturer, over 60: William Latham; made bloody horrible things…Giger did science fiction things. But he never actually made any of these things. They were photographic, digital sculptures, the only way he could make them was to carve them by hand which may not be a bad thing.

(16:15) Facilitator: So when 2D printers came out, a lot of people were building their own printers and playing around with them. And the media went crazy saying it's the end of power and it's going to challenge the ways of distribution especially home-based printing. But when you stop and think about what printing has become, I bet most of you have a printer at home and don't even use it.

(16:46) Photography lecturer, 50-60: No.

(16:48) Facilitator: And what/when would you ever use it for a creative purpose? You would mainly use it to print your Ryanair tickets.

(16:55) Painting lecturer, over 60: You would use it to archive something, but the architecture degree show right now in the sculpture court has a lot of evidence of 3D printing and the digital. And then particularly in the… it was previously laser etched and it was really sterile and I think now they're beginning to rasterize it to make a tone: rather than just a line. And the contrast between the line and the tone and the hand drawn and some of them have gone and embossed something using etching: not digital but physical etching over the top and I think it becomes part of a language, it might come into it's own a bit more as an extension of your toolkit.

(18:04) Art lecturer, 40-50: Because for a while laser cutting was just everywhere and lace too. And I think this will go through the same phase, but it's only really this year that art students are getting their paws on this technology. Doing digital courses.

(18:48) Facilitator: It's to do with the department as well. Because I was trying to get people from the school to work with me and now they are starting to be more interested but before it was like 3D printing 'oh yeah I need some boxes for something'. And the same problem goes for painting.

(19:10) Painting lecturer, over 60: It's not easy 3D printing, but one student used laser cutting to construct a painting of tiny butterflies. 3D dimensional painting out of four flats built into a box. You can see through it. You can get more gestural things in amongst the lattice work. But he was fiddling with that in second year and now he is just beginning to get a hand on the language. And you could argue the language he is applying now is as sophisticated as it was in second year. He still has a distance to go to keep the language up to level he could have achieved by hand. So it's a progression and it's just getting used to it, like drawing with your left hand.

(20:30) Facilitator: So to move away from the focus of my research and try and get a different angle is to say, what if this is not 3D printing when I look at it. So I'm trying to get a sense of how digital technologies or other technologies influence creative practices. It doesn't need to be digital; it can be any other technology. We had a conversation a few weeks ago about how limiting it can be using technology in a certain environment. Would you say this new emerging technology influence those environments somehow? They simplify the processes? They open new opportunities? How do you see that within your process?

(21:19) Musician and lecturer, 30-40: Computer music and computer music performers have been struggling with this for a long time. Performers for a start walking up on stage with a violin and drum kit: you can see the intentions. But when you come onstage with a laptop there are things you can not see. A new set of values that the audience have been placing on this activity. There's a lot of criticism of laptop performers that are sitting there checking their email, while the gigs going on: not making music for the audience. Because technologies are in their infancy as instruments, you think of a violin as having all this time to evolve and become established as part of our culture. And these things (laptops) are so multipurpose: you check your email, you render a 3D object…you do everything with these things. There's always questions in the audience's mind about what people are doing. So the technology is really interfering with the music. But it's settling down now because everybody understands you can do anything with it. Sometimes it seems strange to see a band onstage without a laptop: it's expected because it adds a dimension that shows relevant thinking. But you can not make music in the same way.

(23:04) Art lecturer, 50-60: And things are always changing. I've particularly found it a bit daunting what you can do with this, or that, or that. It seems there's 10 or 15 different programs you could use to do the same thing. That's what I find intimidating.

(23:24) Art lecturer, 40-50: They are I suppose just other tools, like an old camera or your digital camera.

(23:33) Art lecturer, 50-60: With a bit of practice you get up to speed with something, but it changes and changes which is a good thing.

(23:42) Photography lecturer, 50-60: And usually most cutting edge developments in arts, seem to be accompanied by the "my granny could do that" response. But it's the ideas that carry it through; so it's the extent to which you can invest this with original ideas and I think it's entirely possible. But you're playing on the notion of infinite reproducibility. Like craftwork, infinitely repeating and reflecting industrial society; it's built into the concept that this is something very, very simple. Almost boring, but for a technical virtuoso listening to that, they could be like "what am I listening to? These guys are just churning out the same rhythm" and yet other people regard them as some of the greatest composers of that particular period. That debate will always go on; it always has. This just raises it up again.

(24:58) Painting lecturer, over 60: I think also; this is very in it's stone age too. In the school, ever since we've had to go to safe processes, we have to use different materials; it's a hit and miss to get the quality and the graduate assistants and technicians have to use laser cutting to get the depth of an etch we might have got from old processes. And when we had to go to this thing, the assistant vice principal said "you have to ban oil based materials". So we banned it from screen-printing which is fair enough because it can come back in your face. But oil based ink gives a real quality of colour and depth and tone: we had to ban it and use water based stuff. We can not use acid because it's dangerous. So you come down to the lowest common denominator, and it becomes like potato printing again. It becomes something where, you could do it in the kitchen, that's not what we should be doing; we should be having dangerous stuff and if you go to the United States, where they're most health and safety aware; they're still using the acid and found a way to do it safely. Oil based isn't the same as solvent based because it's linseed, you can wash your dishes in it. So what we are having to do now is find a new way to make a plate; so etching into steel using the equivalent of this. This is building it up (3D printing) and we're looking at cutting it away. Reversing your process.

you've got a student doing a particularly bad drawing they keep adding stuff; when the job is to remove stuff. So with this (3D printer) and the idea of cutting into things; it can expand the vocabulary.

(27:45) Photography lecturer, 50-60: So this new stuff working in tandem with what already exists is not necessarily supplanted? Not to repeat myself, but it's very interesting that email came through just now about photography. We run a fair amount of student practices around film and in fact a lot of fine artists still use film as opposed to digital. And there's been a bit of debate about a machine that's gone down this expensive "do we replace it or not?" and something came through just now saying it looks like it is going to be replaced. On the back of that the local businessman is saying 'I don't have film processor anymore, can I come into the university and process commercially from artists out there? You think those days are gone, nobody uses film these days, but it is quite the reverse. People still need it.

(28:40) Painting lecturer, over 60: The artist that does chalkboard drawings of ships, one of the things she did many years ago was quoting coal ridge. But recently she's been trying to identify where film.

(29:07) Photography lecturer, 50-60: Tacita?

(29:11) Painting lecturer, over 60: She's trying to find somewhere, whether it's endangered objects or endangered processes. And she's trying to find somebody who will preserve film because nobody wants to take responsibility for it.

(29:27) Photography lecturer, 50-60: You know Neil Young, he did it through Kick starter; he has always hated CD quality of music and this converts as best as it can from your MP3 player, $400 a pop.

(30:03) Painting lecturer, over 60: But it's still a facsimile, because he gets to that digitally and you add noise. Like in Photoshop you add speckle.

(30:18) Photography lecturer, 50-60: What you have with American photographers: you have to be very wealthy to do this, but they shoot everything in megapixels and it's saved on 5 X 4 film. It's archaically sound.

(30:43) Painting lecturer, over 60: Film will last longer than a digital file.

(30:48) Photography lecturer, 50-60: Well the thing is, they can get corrupted.

(30:51) Painting lecturer, over 60: Two years ago the technology they used to make high quality digital art prints is now gone. The settings you used to make that print are gone. So you can not make an addition after two years. Whereas using traditional etching you probably could, so as well as gathering the prints they're gathering the equipment it was made in to play back their tapes. Image and form is important; I don't know where this leaves 3D printing.

(31:46) Facilitator: I think it's quite similar yeah, in a sense it's going through a flow of constant change.

(31:55) Musician and lecturer, 30-40: Just while we're talking about changes in photography, talking about Lightdow Ellium. You can take a photograph and say I want to take your eye. It takes and records all the different angles of the light and it records a massive file, but then you can zoom into any angle. All the work is done afterwards.

(34:18) Musician and lecturer, 30-40: You can have this view where it looks 3D.

(34:28) Art lecturer, 40-50: Has it got multiple lenses?

(34:32) Musician and lecturer, 30-40: I think it's just one lens. But the way the chip captures the light: the chips are directional.

(36:12) Photography lecturer, 50-60: I was going to ask you a question about music, lets say you're listening to Pablo Casals 1920 (cellist). And you listen to a modern version of it. I was involved in it in an infographic sense, there was 200 drop ins (on the track) and the engineers reckoned this was about average for a monumental piece. But when you listen to that, it's not a performance as opposed to the Casal concert when you know he sat through it from start to finish. You move from that to this.

(37:16) Musician and lecturer, 30-40: Well recordings are one thing and concerts are another. You've got to think if you're making a recording, it doesn't matter because it's already artificial: it's going to be played back on loudspeakers and it's already mediated at the point of conception.

(37:30) Painting lecturer, over 60: In Casal's day that was the only way to make a recording, very different thing.

(37:35) Musician and lecturer, 30-40: And it leads to different objects. I don't know if there's a qualitative issue? But they're just different things so I find it hard to compare.

(37:50) Painting lecturer, over 60: It's a qualitative shift though.

(38:00) Facilitator: I heard once that Louis Armstrong was actually going to make a recording and he forgot what he had to sing and started muttering things and that's how the song was made. Because it was a wax block they were recording on: they couldn't stop it. There was a time when performance was related to rercording

(38:38) Photography lecturer, 50-60: This idea of accident, mistake and imperfection. I worry with this new super control; is how do you retain that happenstance element that even happens in photography?

(38:54) Facilitator: You have a lot of control but there are many things you cannot control. For instance, I've tried so many times to do the same print and it doesn't turn out to be the same print. So there is a certain level of replicability, but some things will never be the same.

(39:16) Musician and lecturer, 30-40: We must have made lots of little mistakes and affordances on the trip to converting from the image to the thing. So setting a threshold for your vector to image or vice versa; that's a specific decision and once you've made that decision you follow it through and then it turns out; actually if I'd made the threshold like this…so we're improvising with these technologies. I know it feels controlled but…

(39:48) Ceramist, 50-60: There's always the thing where you press the button though and it is done. Not even, nowadays you can do so much other stuff with it.

(39:57) Facilitator: Last time we were talking about that and we went back to clay modelling. Someone said, what was the name of the tool?

(40:07) Ceramist, 50-60: Clay tool.

(40:10) Facilitator: The clay tool was far more flexible than any of the software we're using or could think of and I don't know if I agree or disagree. But what are your thoughts on that?

(40:22) Painting lecturer, over 60: It's the equivalent of Photoshop trying to emulate the oil with a brush on a linen canvas. It's still starting from the real, but it's trying to give you a version of that….it still has to use the original as its source, it's always going to be a facsimile of that and you're never going to get that. I think the idea of trying to make the experience as real as possible so that when you're touching the brush onto a particularly weight of canvas; you feel a drag, so that you know how it works. But I don't know what difference that makes, I'd quite like a digital painting to look like a digital painting: truth to materials and integrity to the relationship and the idea. It all comes back to the idea. What are you finding out when you're doing this? Where is your control? What are you measuring it against? And if all we're measuring it against is the original then maybe that is wrong. I think this has to come into its own rather than duping the original thing. It's got its own language and its own integrity.

(42:22) Ceramist, 50-60: It's shares some stuff with casting, because you can make copies of something and that was the old technology to do something. All of us are coming in from different backgrounds and everyone is seeing how its very similar to what they do in one respect. I mean we all think it looks like textiles, its got a lot to do with photography and sculpture but it is all somewhere else as well. At first there is a concern about these sorts of things, but in actual fact once you know how things are going to come out: there's a grain. There's a type of bronze casting in India where they make things out of strings of wax because it's cheaper and I was going to ask you if you could scan one of those for me, because they are all linear, they all look like close-ups of this.

(43:38) Facilitator: If you keep scanning and 3D printing you will end up with…

(43:40) Ceramist, 50-60: A mutation?

(43:48) Musician and lecturer, 30-40: The feedback. It probably all just ends up as a blob.

(44:00) Facilitator:

(45:06) Musician and lecturer, 30-40: Is there a place where all these heads can be seen in a row?

(45:10) Facilitator: You can find them online.

(45:36) Ceramist, 50-60: So you made it and asked students to, so they manipulated things digitally? There is a tendency when we are faced with doing something jokey – even in the last workshop, when everybody was asked to do something everybody just does a thing they would have done when they just started at school. You default to that old animal or a tree.

(46:38) Facilitator: So you would agree that the interesting thing is the idea or the medium?

(45:42) Musician and lecturer, 30-40: Everything.

(46:46) Painting lecturer, over 60: But then the medium is going to allow you to do things that you couldn't do in any other way. The medium is the message.

(46:57) Photography lecturer, 50-60: Absolutely, it is the managing of form and content. It's a debate we don't have often enough at all. Because then you can position things like painting and photography in their rightful kind of place. And in that sense, paintings are very familiar and you will see that knowledge. But I won't and vice versa. It isn't just about ideas regardless of the medium, but anyway I won't go there. The form is the content. And that would be how this process [3D printing] for me would succeed in artistic terms, whether there is something more than lip service given to the way this thing is made; rather than there's the object. This [3D printed copy of vase] isn't a replacement for that [original vase made with clay], how can it be? For me it's just a non starter really.

(48:19) Ceramist, 50-60: I'm thinking about it's limitations are and the scale of it just limits it completely. It would be like you could only paint on a very small canvas and you could do something amazing, but it had to be that size. That will be the one thing that limits it's use for degree shows.

(48:45) Painting lecturer, over 60: The limitation is a great freedom. If you put a limitation on something, you really have to work hard within it and that allows you to be free within it and say anything goes. Any artist will work really well within limitation. You only have this amount of time, or these materials or you have to work within this size with these constraints. And if you get 20 different people doing that, you'll get a load of different responses. If you just say anything goes, you'll probably get some very similar things: the limitation gives you a structure to work in.

(49:49) Photography lecturer, 50-60: It's most obvious, going back if you listen to Robert Johnson he was a genius. Black and white photography that's all you've got; move me!

(50:05) Painting lecturer, over 60: Or you've got 24 exposures and that's really important; the preciousness of it. And it's that ubiquitous nature of the technology or things that changes the way that we use them. It's like saying it's just a sketch: well get it right.

(50:42) Musician and lecturer, 30-40: Yeah or it just changes some other aspects of the whole thing. So if you take 500 photographs then the process is not to do with taking photographs anymore, but to do with selection, storing and so on. So the emphasis of where the artfulness and the skill changes its position in the process. But it doesn't necessarily mean those things of skill and care disappear, they just move from one place to another.

(51:17) Painting lecturer, over 60: I wonder if the 499th one will be as good as the 3rd one. 500 it could be 5000; you just keep going.

(51:31) Musician and lecturer, 30-40: Then you make different things with that, so if you're talking about making a refined thing with the materials you've got. You make a different thing with 5000 photos, you don't anymore print a big photograph out and stick it on the wall. You do things in another way and that's how things shift. And if you do choose to go in another way; you stick your 4724th photograph up on the wall then that becomes something very special, or has the potential to become very special because its value has become incredibly rare.

(52:15) Photography lecturer, 50-60: I'm old enough to get away with saying this kind of stuff now, this stuff is always going to baffle me. It seems to me with student photographers and myself you transpose your analogue skills into digital. I have no idea what it might be like to start up digitally; which most people do these days. But the best people working digitally are those who are the best working with analogue.

(52:49) Musician and lecturer, 30-40: That's only if you have the frame of judgement of an analogue perspective. We are faced with this challenge of trying to re-understand what it is we're doing.

(53:08) Facilitator: Finding new meaning or shifting medium which is very interesting and something I'm trying to tap into with 3D printing. It doesn't belong to any type of medium people are using and how might you use it?

(53:23) Photography lecturer, 50-60: I still think you'll find the artist that uses that best, if you believe in things as 'best artists', then they'll bring a sensibility to this. Music again, I keep going on about synthesizers, for me one of the very few people who uses a synthesizer to its best was Pete Tangent [low quality recording]. And that's his analogue sensibility brought into that. Other people just turn out drivel as far as I know. He's one who was an outstanding conventional pop musician, he transformed it and pushed the envelope in that area. But he already had that (before he touched a synthesizer) it was already there. Starting with this stuff, I can not imagine. If you had no reference points.

(54:31) Facilitator: It would open a different way of learning and actually what I have seen with people with digital cameras. I knew that if I threw away my 24 or my 56 I would need to pay a lot of money and maybe I would get crap after that. So I was very selective. I have seen people learning with a digital camera and they had a view of it as 'it's not very good, lets take another 100. Out of 100 what is going to be good? To develop that sensitivity/sensibility. But that is not our view because we have a certain age.

(55:23) Photography lecturer, 50-60: I love digital. Personally it's just transformed what I do totally; turned it inside out. Because I am obsessive about perfection. I don't mean things being clinically perfect or perfection being wrong. You can shoot thousands of files and I do to get it right and that's so liberating. It doesn't necessarily look like that at the end of the day but you can play around with focus. If you were shooting film you'd be bankrupt, I just love it personally.

(56:05) Painting lecturer, over 60: When you're starting from, it's a long time ago now but, kids. When my oldest one who was about ten and telling the time, he just kept saying 'oh it's 21:22 or 21:30' and I thought, can he not read the time? When I read the time it was half past 9. His idea of digital time was linear and my idea of time had a shape to it; like that's how much time I have left. But from then (to his son) it was just, one number follows another number and he didn't understand that 45 minutes is ¾ of a circle. So I know what a clock can do in that time. And I was converting real time to analogue time, they didn't, they started from digital numbers and now that they have watches there's something lost about the shape of time and cyclical nature of its form. The clock started ticking 28 years ago and it's still ticking.

(58:54) Facilitator: Would you mind people in 60 years were having similar conversations talking about people who actually starting learning on digital and moved to analogue. Or there is something beyond the digital that is even more digital.

(58:12) Musician and lecturer, 30-40: I think there is a shift anyway, but there is something interesting happening. We won't be talking about these questions this way anymore, we'll be talking in environmental terms, the question of analogue or digital isn't going to matter, but whether it is sustainable. There will be other sorts of terms we'll need to start using soon in order to come to some reconciliation between our abilities and our hopes. Because they're not well aligned and it's unlikely it will be looked upon as PC or modernistic if we carry on having these sorts of debates because they're not taking us anywhere further. So to make progress, the questions we'll be asking will be about art and our abilities are going to be framed in that sort of way.

(59:32) Facilitator: That's the point of digital, the seemingly no difference between what is digital or not [undistinguishable]. It's happening with gender as well, there is no male and female anymore: there is something in between, neutral.

(59:48) Photography lecturer, 50-60: Absolutely and it's been officially recognized in Germany. Well that opens it out, it's kind of beyond me to be honest [referring to the debate of digital versus analogue].

(1:00:20) Painting lecturer, over 60: I'm not sure about that, because if you ask a different question are you avoiding the issue? If I interrogate it this way, it will give me another set of answers and do these set of answers eliminate things or help us progress? Or are we forgetting something else. As we convert from a perspective to another, which is what any person does; there are certain limitations I use to evaluate it. And I could use a different set of tools to evaluate it but to use a metaphor; using a hammer when I should be using a screwdriver; I'm not going to get the result I want.

(1:01:12) Musician and lecturer, 30-40: No absolutely it's a different thing, but then the relevancy of the results are in question.

(1:01:25) Photography lecturer, 50-60: But the subject matter is always the same, call me extremely old fashioned but it is. And in some ways it's wonderfully irrelevant, but it's always the same. As an artist, and this might be the difference between art and design, but how do you make sense of being a human being? You do it with the tools that are available to you and they change. But that fundamental thing, it isn't ever going to change, you use the tools that are available that mutates, changes and looks incredibly different. In fact, we're all saying 'what the fuck is going on here' they're fundamental philosophical things that I can not see ever changing. A caveman picking up a stick; I wasn't around at the time [participants name] believe it or not!

(1:02:22) Painting lecturer, over 60: […]

(1:02:32) Facilitator: Is that kind of thing happening to the handmade as well? And do you understand the handmade? Is there any difference between something that is handmade in the 1st century and something handmade today?

(1:02:52) Ceramist, 50-60: Well what is handmade? Is that handmade? Because your hand should never be touching your oil paint. The way you interact with that machine is quite hands on.

(1:03:25) Photography lecturer, 50-60: That will change very, very quickly won't it.

(1:03:29) Art lecturer, 40-50: Well the 3D printers I've encountered before are the ones that are sealed units. Someone that knows what they're doing types in what needs to be done and mysteriously you come 3 hours later and it is removed. But there is no sense of someone wading in there and changing the colours as they come through.

(1:03:46) Facilitator: It's starting to happen now; it's getting more handmade.

(1:03:55) Painting lecturer, over 60: Once the first one breaks; it's handmade because someone comes in and fixes it. I could customize it and cut this thing off and I could add that bit; it does become handmade. It's like clay tool, you shape a piece of wood to do something.

(1:04:22) Photography lecturer, 50-60: What these things do is attract boffins and it takes a while to settle down. But the amount of shit that has been produced on these things is terrible.

(1:05:00) Facilitator: What is interesting to me, is how far something can move and still be considered handmade. For instance, a glassblower will never touch the glass; but it is still considered handmade.

(1:05:21) Photography lecturer, 50-60: It's been a long time since Duchamp put a urinal in a gallery.

(1:05:32) Painting lecturer, over 60: When somebody does something it frees things up: oh that's that now. Painting used to be a school in itself; sculpture was a school in itself and within that was other things and we amalgamated and photography came onboard. Across art, everybody who's got a camera isn't a photographer, everybody who's got a paintbrush isn't a painter but what that did do is; if you're coming to do painting: that's what you're doing. You're not doing this generic mush. You can define the characteristics of what you do. That's where the good debate comes; if you have four people, someone from photography, intermedia, painting and sculpture all talking about a portrait, you're really going to get down to what that portrait is from different perspectives. If four people from painting did it, it becomes similar. Blending things together, you do create these artificial but necessary boundaries. You argue when you get to the edge of one and you peak over into another one; it influences what you're doing. So Duchamp did a good thing.

(1:07:00) Photography lecturer, 50-60: But the notion of the readymade is long established in the art context.

(1:07:10) Musician and lecturer, 30-40: I always thought Duchamp was trying to get you to not bother with galleries anymore, maybe these sorts of technologies and the massiveness of them will help break institutional things down a bit.

(1:07:29) Photography lecturer, 50-60: Some people do and some people don't and that's always going to be the case.

(1:07:32) Musician and lecturer, 30-40: Well if you put mass produced urinals in galleries because we don't respect them anymore and you rarefy all that stuff. And then it turns out there's a whole host of people thanks to the ease of use of these technologies that are making just as good stuff, but no bothering to show it in galleries because that whole area is completely irrelevant. But it feels like it takes a century for the work of Duchamp to finally have any serious consequence; because nobody is going to galleries or concerts anymore.

(1:08:18) Photography lecturer, 50-60: I think he was maybe saying more than that, but I don't know enough about him.

(1:08:25) Ceramist, 50-60: Yeah, because nobody did go out to the equivalent of B&Q and buy themselves a urinal and say they've got their piece of art. And again this is something apart from ready-mades, can people produce something exactly? I suppose you can. But everything we'll be doing, they're one off things that artists would tend to do.

(1:09:09) Photography lecturer, 50-60: Unless you're alluding to the fact that in contemporary society we're all churning out the same stuff. It's something built in there that refers back to this somehow. In the business of multiple reproductions, it's perfectly acceptable.

(1:09:36) Painting lecturer, over 60: So he's got a palette or a vocabulary, he makes multiples out of multiples. There's a component, a component and a component. You put four of these ones together and you get one shape; and you put three of these ones and one of these ones together and you get that shape so there's a field. An Anthony Gormley field, but these are cast and put together. So each one of these components is a one off and yet at first glance…I suppose it has to do with consumerism and you go into a shop or an online catalogue: you want it all and you buy that one; but you need the mass. It's like kids collecting Pokémon cards: its not one of them; you have to collect the whole set.

(1:10:42) Ceramist, 50-60: That's the same way the emperor's army were built, which they all look different and were thought of as portraits. But they had people that just made legs and people that just made heads and they were added together.

(1:10:54) Painting lecturer, over 60: It's like in tapestries; somebody specialized in flowers, somebody specialized in legs, somebody specialized in hands and they would weave these different bits because that's what they knew about.

(1:11:13) Musician and lecturer, 30-40: Maybe that's what we should do; we should get together for another 3D workshop and make components that fit together.

(1:11:20) Painting lecturer, over 60: Chinese whispers.

(1:11:28) Musician and lecturer, 30-40: You've got to make a hole that's 5mm wide and 3mm deep and I've got to make something that protrudes by those dimensions.

(1:11:47) Ceramist, 50-60: I think that's exactly what Facilitator had us doing last time, except it was with clay and a lot of folk haven't used clay since they were five; so it was all a bit random. But it was seeing what happened if people adapted something that arrived in their hands as an object already. But we're all a bit reticent.

(1:12:28) Painting lecturer, over 60: We used to do that in all day drawing classes where every half hour you passed your drawing onto someone else and you'd say "what are you doing?" and they'd be like "I'm doing this!". But what it did do is take away the preciousness of getting it right. Sometimes the thing you should chuck out is the best bit. Sometimes in an exhibition they'll put the whole thing in, someone's got to take something away to make room.

(1:13:27) Musician and lecturer, 30-40: To give something away is hard to do.

(1:13:58) Musician and lecturer, 30-40: Brilliant

(1:14:21) Ceramist, 50-60: It can not be read as it is because of the scale of it, but it's all about experimenting.

(1:16:50) Photography lecturer, 50-60: It is fascinating to go from this, to that regardless. To look at that and think, I was standing on a beach in Majorca ten years ago and my son was playing with a gun. And it ends up like that, whether through this technology or not there's still a trace of the real there. The first people to capitalize on this will be wedding photographers, same with videos they'll be right into this. They do it in ASDA already.

(1:18:55) Art lecturer, 40-50: It's very odd and very interesting.

(1:19:15) Painting lecturer, over 60: I made a mistake with the edge, that bothers me.

(1:20:05) Photography lecturer, 50-60: This machine is so horrible and slow.

(1:24:15) Musician and lecturer, 30-40: I do lots of free improv and I stick it through my computer. That's my favourite thing to do.

End of Transcript.

10.4. APPENDIX D: TRANSCRIPTS FROM INTERVIEWS

Jen Deschenes interview

(1:02) J: I do a lot of drawing and embroidery, so it's a combination of screen printing and embroidery. So I do all these hand embroideries with little hooks so I do every stitch.

(1:48) D: So why are you interested in 3D printing?

(1:50) J: Well I don't know, it was you that told me…I remember you said I should come and see you and I said 'I don't know how it would work with my work' and you said I might be pleasantly surprised.

(2:18) D: I've been working with textile design. And we've done some tests on fabric just using this machine and to see if we could print on it and actually it works quite well. So it would be really easy to have a digital design imported on top of the fabric. Then you will say 'I'm a craft practitioner and how will you perceive that?'

(2:56) J: It does look like its almost been heat pressed on plastic.

(3:00) D: Very similar process.

(3:07) J: I did look online after speaking to you and there's some amazing stuff textile wise. But it's very intricate structures. Kind of like lace and things like that.

(3:17) D: And it's a different process.

(3:28) J: But you are looking at almost like a printing process.

(3:34) D: Actually what this thing does is, you give it a model and then it builds it layer by layer. So that allows you to put any material before the process, after, or during the process. So I was trying to do some experiments with textiles and after a while, we realised it would be possible to interact with it as it goes. So we started using it as a sewing machine.

(4:42) J: And how easy is this to come off? Quite easy?

(4:45) D: Yeah, that one peals off, but this one is a working process. But there are many other ways of using it, that's what I'm trying to address, I'm trying to find people who find a common motivation between the digital and their practices. And see how we can find a way of using it.

(5:12) J: What I would be interested in, if anything would be if you could recreate embroideries and intricate structures that would be done by hand: like woven things or beaded things.

(5:34) D: Later on you could bring it into the textile, or you are just thinking about the designs you have seen online?

(5:45) J: No, they were phenomenal and would obviously cost a lot of money. They were high end prototypes for design houses, which I don't have the money to do.

(6:04) D: I can tell you this machine cost around 300 dollars, so it was expensive to get it to the UK…

(7:03) J: It does have a very bone like structure. Is there always one type of plastic you use?

(7:07) D: No there are many types. You can even make it with some kind of wood/wool thing rather than with plastic. And some other kind of experiments I'm doing is with people from the university, we are trying to find the recipe for glass.

(7:27) J: Oh wow, I like that.

(7:33) D: And ceramics as well. So basically we'll replace this with a component that will allow us to put in a syringe and we will print it with that syringe.

(7:47) J: Could you make these glass beads? That would represent a path and then somehow stitch them onto the fabric?

(7:58) D: Sure, but what can be done right now are things like that or…

(8:22) J: Because in its nature it is very textile-y, because it's something that's made up of threads and layers and has a structure.

(8:34) D: That's why I thought it might be relevant if you wanted to experiment.

(8:43) J: Be interesting to get because I work with a lot of old materials and I find old embroideries to try and recreate some of those structures.

(8:59) D: Actually one of my last projects was to 3D scan an oyster and making a box out of it for a jeweller. So I think there is a really interesting challenge working with embroidery and it's that 'how do we capture that to make it digital?' That's really difficult, unless we scan it.

(9:38) J: Yeah, well it's more like a surface application like a print, rather than actual embroidery.

(9:48) D: So that would be the challenge to solve and experiment with the materials.

(9:55) J: And because it's not going through the fabric, how do you stop it from peeling off?

(10:00) D: Well, that's one of the things I've been thinking of, but it depends on the fabric as well. This is nylon not polyester.

(10:14) J: Yeah, it's a synthetic.

(10:16) D: Polyester for instance, there are things which can be done. You can attach here and here and if you manage the temperature right, you might be able to melt the polyester without damaging it.

(10:30) J: Because it's a synthetic material, it already has a plastic in it. So it's easier to bond another plastic to it.

(10:38) D: Well, if we're talking about cotton, I have not tried so there is another challenge. Which materials do you work with? (10:52) J: Mainly silks and natural linens. But that's Devore prints, so the fabric is silk viscose. Because when you print it, the print basically burns out the natural and leaves the synthetic fibres.

(11:23) D: There are different things that could be done, for instance we'll be following that line and experimenting with a combination of materials. And you might be able to get something out of that. But the other thing would be to start testing out processes or methods. One of the things I was considering is, adding a needle here or making this a tiny nozzle. Making that longer (the nozzle) so you can puncture through the textile and extrude at different points. But that requires a lot of mechanical work. But if it was relevant I wouldn't mind doing it.

One thing would be to capture this and then recreate it. Have you ever tried scanning any of your embroidery?

(12:57) J: No, I've never actually just scanned them. I've never had any reason to. So you think I should scan in some embroideries and

(13:21) D: Give them to me and I'll work with it, or I can show you the process behind this and you can experiment with it a little.

(13:43) J: There's kind of two things: the surface thing and then there's the actual structure.

(14:03) D: Yeah, there are many different materials, one of them is wood and trying to make my own things in glass and ceramics. So we wouldn't just be restricted to plastic

(14:18) J: Yeah, I like the glass

(14:22) D: The glass is more challenging because it's experimental, there are people doing things with ceramics or wood but glass is not that common.

(14:36) J: But the way I think of the glass being used is because I take these knitting patterns, but I turn them into embroideries and I use glass beads. So It just makes me think of a dotted out design with glass, but I don't know how that would work.

(15:41) D: I'm using a really easy to use software.

(16:00) J: So you did this for a jewellery designer?

(16:02) D: I did this for a graphic designer that was doing it for a jewellery designer. Have you ever used illustrator or Indesign?

(16:43) J: I'm rubbish on the computer, I do everything by hand.

(16:48) D: Everything?

(16:49) J: Yeah.

(17:04) D: Well, this software is called Tinker CAD. It's fairly easy to use. They have tutorials so it's really easy.

(17:53) J: Really easy, question mark.

(18:00) D: It works in a very traditional way, following a very traditional path of designing things with computers. You have a geometry and then you subtract a geometry. Interesting thing about this software is it's really easy to import 2D designs. Once you have a file of a scan, you can say you want it to have a geometry and it gives the geometry automatically. You can print it straight away.

(20:38) J: So the best way of taking something to scan it?

(20:45) D: There are different ways of capturing volumes but for now we're working with fairly flat things.

(21:11) J: And the materials you can use with this are mainly plastics.

(21:18) D: For now, it is at this stage I can mainly use plastics. But I'm working on a new programme. (In Tinker CAD) it's really difficult to get something organic. (22:29) There is another programme that is pressure sensitive, so it can be used on tablets and it's called Sculptris.

(23:41) D: Basically you can import any geometry you like, but normally you start with a bowl.

(23:53) J: Why do you start with a bowl?

(23:56) D: It's based on clay modelling, they developed it for analysing clay modelling behaviour. There is crease, rotate, skin, flatten, draw inflate…so we are carving something out, inverting it.

(26:41) D: What do you think about 3D printing?

(26:46) J: Well new technology is a good thing, I'm so fascinated by the past and trying to recreate things that people don't do anymore: like embroidering and doing things by hand. So it would be interesting to see how I could apply that.

(27:15) D: Do you see any challenge arising from your interest

(27:22) J: No

(27:24) D: Why are you so sure?

(27:26) J: Because I just do what I do. I'm an artist I'm trying to say something with my work, I'm not trying to be commercially viable. So I don't see how it would challenge what I do? Because I'm trying to challenge people to think about the way things are done anyway.

(27:58) D: Why do you think other practitioners might respect it?

(28:03) J: Probably because they make things by hand and there's this thing that can make it faster: all things. That is the way of the world anyway, regardless of what anybody does, we're always trying to look for cheaper ways to produce things and male it easier. Because of that, the things that were before done by hand and were time-consuming become defunct. But that's just the nature of the world.

(28:47) D: And of craft as well.

(28:54) J: Yeah, but I think if you're making, your trying to say something and tell a story with your work. And sometimes you can use other things to help that story along. Other times you might reject them because they are not going to. Especially if you don't make anything yourself, nobody will be able to understand the length of time that goes into making anything. Even for you, setting all this us maybe…but it's taken a lot of time and it's an art form in itself. You're not able to just whip up an amazing thing, but that's just the nature of the different things people tend to do. I don't know why I feel frightened.

(29:54) D: It's a question that I get and it happened for instance with microwaves. I remember when microwaves were changing cooking and were set to change cooking forever.

(30:18) J: But that’s the thing, people quite often fear change.

(30:25) D: But if you’re an artist you should be working with it and those materials.

(30:33) J: Yeah, if there is a way of cooperating and doing something interesting then why not?

(31:09) D: We ran a workshop with three craft practitioners; one was a silversmith, a stone mason and a ceramist. At the beginning they were not enthusiastic to work on it. They got so hooked one of them bought a laptop and he’s doing designs all the time. It’s really easy to navigate. You can work on geometries in a very dynamic way.

(32:27) J: This one, it’s less importing something and more sculpting something?

(32:33) D: Yeah, It’s mainly designed for you to make things, not print things. But you could print them if you wanted. And you can find a combination of organic and non-organic shapes (on the programme Tinker CAD)

(33:09) J: But you need to keep it simple.

(33:12) D: No I can print really complex geometries. I didn’t print that on this one, but I can get the same effect. For instance, this is the support material that will hold the print.

(33:36) J: It’s a woven material.

(33:44) D: Yeah, for instance that…what happens is, as it is going layer by layer; it can print things inside of things. So we could have a ball and inside of that, we have that (the object being pointed to). It doesn’t involve any extra cost or any extra time, it just builds.

(34:11) J: Does it prefer these kinds of geometric things to more organic shapes?

(34:18) D: The thing is, this has been very intelligently designed and it’s been designed so it doesn’t need support material. Support material in these low level printers is a little bit tricky. For instance, in the process of this one: it took about an hour because I was sanding it quite a lot. But you have to break the support material away, clean it and sand it. I made this one in another machine and it makes the support material really thin so you don’t need to clean it. This is some models… some waste material.

(35:46) J: Oh that's lovely.

(35:54) D: Sometimes I enjoy letting it go with crazy things like that.

(36:10) J: So you could create embroideries and structures and take the structure if the French knot, make it in ceramics and then embroider onto it.

(36:30) D: Or even whatever you think of, we could get a really complex structure.

(36:35) J: You could make hundreds of them and then hand embroider them on. Yeah, I think it's really difficult to use it as a print. It might work on something like a silk viscose.

(37:07) D: We will need to try, next time you come you could bring some?

(37:17) J: I could even take a bit that I've already printed and then do something on top. And make things you can grow your own. (37:42) This also reminds me of white work embroidery; when you'd embroider it so you can cut shapes out and it stays. So you could do intricate designs and create new structures.

(38:33) D: This is quite common

(38:35) J: Yes! It used to be done all the time. But people don't pay attention to things anymore if you don't see them anymore or think about the complexity of it: it becomes passé.

(39:27) D: There are a few other things you can play with and what you place inside. For instance, you can have a volume and decide the pattern inside of it. With a bit of pacing you can design your own pattern to fill in the geometry…embroidering the inner body of it. Can we find one here?

(40:21) J: So those hexagons are designed to be seen like that?

(40:27) D: Not really they're designed to support the geometry from the inside.

(40:35) J: The honeycomb, that's supposed to be the strongest structure.

(41:21) D: So you said you were from the Shetlands

(41:23) J: I'm from the Shetlands, but I live in the highlands near Fort William.

(41:35) D: Is there any relation between the place you live and Edinburgh?

(41:39) J: No, all my work is based around being in Shetland. I always draw a lot of boats, when I was little because I'm from a really small island, all the men in my family were fishermen. I remember thinking when I was little 'that's all that boys do: boats, boats, boats'. And when I went off to my granny's house to play in the loft: all the old books were completely covered with drawings of boats and I just really liked it. And culturally coming from Shetland it has effected me a lot because I came from such a small place and it was different. I think it's kind of unique in some ways that you can know so much about your past: so many people don't. Textiles is a huge thing in Shetland, but it's mainly knitting. But I like drawing, surface design and I'm just obsessed with textiles in general. And I like to trump the idea of trying to tell a story through a drawing and making a narrative and it just seems like a natural thing to tell a story of my past.

(43:50) I think of it as just telling a story through using materials that you are interested in. I like to use techniques that people don't pay attention to anymore: hand embroidery. Because I want to show they can be seen in a new way and not just the way they're perceived now: in an antique show and disregarded. So many hours of work and time has gone into those things. I just think people look at it differently now. (44:43) D: You said that textiles are really common in Shetland. Is there any embroidery there?

(44:50) J: No, well there is people would have done embroidery when making their own clothes and that kind of thing. But in Shetland, everybody knitted, it was how the woman made a bit of money. Men went off to fish and women would knit. And I print on stockings and in Shetland people say (45:24) 'the man came under sock' (I don't know if I heard this correctly) because apparently in the 1800s they used to knit socks and trade them with the Dutch and German and trade them for goods around Europe. They used to make underwear for comfort and I like to make it for another reason, to show a more luxurious side of it but telling the same sort of story in a different way.

(46:26) D: And your brother are still fishermen.

(46:29) J: Yeah, my dad and my brother are still fishermen.

(46:34) D: And you are living in the middle of the land now.

(46:38) J: Yeah I miss the sea.

(46:41) D: Yeah, I understand that. Sometimes the wind comes up but otherwise you don't feel it, it's too far.

(46:54) J: Something I really miss about Shetland is being close to the sea. Because the island I'm from is just 7 miles by 3, so it's a bit small. So you can see the sea whenever you want.

(47:16) D: And is there a community of people that knit?

(47:29) J: There we go, that's my granny's; my granny knitted that and my mother knitted that. Yeah most people knit, I don't know how much it's being kept up with nowadays. But I think they're trying to promote it and keep it going.

(48:10) D: We should try to keep traditions.

(49:20) J: We had to learn to knit when I was at school it was part of what we did.

(49:31) D: Do boys learn to knit?

(49:35) J: Boys did once upon a time. Boys knitted as well.

(49:39) D: Because it's something you would do with the nets.

(49:43) J: Yeah, that's what I like about it, the structures people made, like my dad can knit and I love the things the men would knit.

(50:02) D: The kind of hook?

(50:04) J: Yeah.

(50:19) D: You get some variation from place to place. (rephrased: The materials they use change from place to place).

(52:27 J: I'll try scanning in things.

(52:29) D: Yeah, that would be great.

(53:06) D: We are still working on it, we need to find a recipe that won't collapse completely because; this was a cube, but it just collapsed. But if you want to keep any of the things that might inspire you then go ahead. I have many plastic!

(54:15) J: So where about were you born?

(54:20) D: Madrid, have you been?

(54:24) J: No I haven't, that's quite inland?

(54:29) D: Yeah it's in the middle, but I've always been nostalgic of the sea.

(57:25) J: That looks like a wave…yeah it feels (the plastic) brittle. And if you added polish you'd be doing a proper weave.

(58:13) D: There is a plastic that dissolves in water. So you could create a pattern, do something with it and get rid of it. You could use pieces of metal and wood and put it in acid. I have to say I'm impressed, it's so tiny.

(1:01:07) J: It really works as a shell because that's the way they are made up.

(1:01:14) D: We yeah, it's how they grow isn't it.

(1:01:31) J: It is such a craft material; it can be paper, it can be textiles, it can be ceramics.

(1:01:41) D: Oh you mean the versatility?

(1:01:43) J: Yeah

(1:01:46) D: But that's the interesting thing, because how do you see plastic as a material for craft?

(1:01:54) J: I don't really like plastic.

(1:01:56) D: Me neither, but it's everywhere. You see the thing this technology is it's giving back the opportunity to do something with plastic. I see plastic as being really undemocratic, before you could barely do anything with plastic and if something was made of plastic you could not amend it. But with this (3D printer) we can start changing that. But on the other hand, would you practice to include plastics? What is the value of plastic?

(1:02:45) J: I don't know, I probably wouldn't unless I liked what it was saying. That's the thing: to do something you like the message from (rephrased - you must like the message you get from the material product). As opposed to just thinking of it as plastic. But I tend to work with really nice materials. Plastic is a funny thing though, it's really since the 50s it has gotten into everything and even with the stockings I do I like using old socks sometimes. They are not that great to wear to be honest, because if you wear them you have to wear them with suspenders to keep them up: they're worn like slouchy socks. But tights, it is the result of plastic that we can wear tights. It depends how you look at things doesn't it? Depends if you can adapt it, that's what I mean.

(1:04:10) D: So what do you think about the materials you work with, special materials?

(1:04:16) J: I work with a lot of silks, glass beads and silk threads.

(1:04:23) D: So would you say that reaction you have to plastic is partially because of the value of the material in itself?

(1:04:32) J: I don't know because I think an awful lot of people don't understand or think about value. They have an ingrained sense of what you think is 'luxury' and what you think is 'valuable'. That doesn't actually mean that anything is more or less valuable than anything else, it's just how we've constructed our society to think. It's true though, because I always think being an artist; pricing things is a nightmare. Because I might spend thirty hours embroidering a collar, but nobody will know. And I think because my idea of value also comes from the fact I work in textiles; nobody values textiles. It's probably the lowest on the scale of value you could get.

(1:05:40) D: That's surprising, I never thought of that.

(1:05:44) J: Because you wear them everyday and you don't think about them. You don't think about the work, time and effort that went into them. And you'll tend to go out and buy cheap textiles; nobody really values them or thinks about them, they're there and are such a massive part of our lives but most people don’t think about them. Someone would pay an awful lot of money for a gold ring, but that might have taken half the time to make, compared to the jumper you’re wearing. It depends how you think about things. For me I value things on sentimentality, it’s about love and the people you care about.

(1:06:46) D: So would you say that you wouldn’t mind using plastic and it would have the same value for you as any other material

(1:06:55) J: I don’t know; it depends what it says. If it fits within a narrative, expresses something you’re trying to say and it can be made nicely then maybe, but I’ve never worked with plastics.

(1:07:15) D: We might change that.

(1:07:25) J: It’s always the story someone has to say, as opposed to what it’s made with.

(1:08:50) J: I think probably the way I’m thinking is, it would be more a combination of trying to this type of printed stuff with cut-out stuff and embroidery on top. So it becomes part of a structure; as opposed to making little things that you could embroider onto.

Recording Finished

Morvern Odling interview

Content

Mo: so did you write the questions?

Together?

Mo: if we miss something we can always go back

K; thanks for coming, introduce myself, I am Karl Diegos PhD colleague, and I kind of know what he has been up to. But in the last year not so much, so you probably know more than I do, the Idea is to get a sense of what has been going on. Maybe in a more impartial way that if you were interviewed by Diego. So feel free to be honest and say evil things about Diego if you feel like it. I think Diego will use your answer to understand how you felt about the collaboration and what impact it has had in your creative practice, and how 3D printing has influenced your work towards the future and maybe other artists as well, so there are 3 questions prepare here, but is really prepared to direct the conversation is not like yes no questions, they are quite open.

K: There are 3 or 4 kinds of questions, I would like to start the conversation chronologically, and before we get there I would like to know more about the background. Do you have any questions? you know we are getting recorded?

I would like you to tell me a bit about your upbringing and family and a little bit about your interests.

Mo: Well, I am Scottish, Irish mother and Scottish father, one brother, and I was born in Australia and moved here when I was 9 months/1 year old. We lived in the west coast, they have both a PhD and my brother is doing his chemistry PhD. I have to go to school. and then we moved outside Edinburgh. Both of my dads parents were artists my grand dad tough in GSA and led an experimental department that is no longer there. So I have always had an strong artistic influence, my folks house is like an old art museum, not sure about how my mother feels about it, although none of my parents did art. My father is a silversmith but for him is more like a creative output, that he enjoys doing because he works as an scientist. But they were always very encouraging, when I was in High school I was either to become a violinist or an artist, but I hate performing so it was an easy choice. Decided to go and do art and after school and naively I decided to become an artist.

K: that paint a very good picture about you. don't know if Diego knows about all this

Mo: we have probably talked about this, but he doesn't have it.

K: that looks like a very interesting background to grow up. What did your grand parents do?

My granny was an engraver, she was a very neat little Scottish lady, she was brought up by her aunt 1920s we had a rhinoceros foot umbrella stands, my father still has some elephant tusks, and loads of random things because they just traveled around the world on those shipping boats, and like shop things and bought them back, and at that time it was very normal, so they brought up my granny. She made huge engraving and embroidery quilt things and loads of still life paintings, landscape mainly. But my grand dad was more experimental with his work, and probably I identify more with his work than with my grannies because he did a lot of portraiture and sculpture. As well of conceptual time based pieces. I still have some of his 8mm cameras and I have them now on video, some of them are just random films like the tide coming in and out. And we have loads of his old sculptures, and you wonder what they are and we don't know. He made music instruments. They kept everything. They lived in this old man house, and they had a church as a studio. I remember very vaguely we sold it when they died.

K:So did you grow up around like a workshop or a studio?

Mo: yeah both my dads, bothed whatever he wanted, and there was like this room that was like dad special workshop, I was allowed in and they taught me how to make a lot of things when I was a kid. and I still make loads of things. and is sad because my grandparents died when I was 16th, so they did not see me go to Art college. Because I took a couple of years to decide what I wanted to do. So they didn't see how much of an influence they had, which is a shame.

K: can you try summarize a little bit how this has influenced your work?

Mo: I guess that the idea that is important is that it is a valid career path, both of my grandparents were working artist, although I never thought of them as academic even though both taught, maybe because they taught quite practical things. My grand dad thought life drawing classes, maybe more like conceptual thinking and I guess I have never put that and academia together even now having spent some time in the art college and seen people describe themselves as academics. But the main influence is that, even though success wise and/or economic wise is not the wisest choice or the easiest choice but I have always seen it as a valid choice. I have a studio, even if I have no money, I feel that you have to have your studio.

K: Its a passion...

Mo: yeah is like a way of living, like a choice, well doesn't feel like much of a choice... it has to be.9

K: OK so can I go back to when you were in school? did you do any technical studies?

Mo: I did art and design all the way through but I didn't take CDT (craft design and technology) mainly because I didn't like the teachers, they were weird, or maybe it did class with something easier that wanted to pass. I did not like school, I hated school all the way through, actually I took one of the evening classes in ECA instead of going to school for half of my 6th year and a chunk of my 5th year, so I could stay in school and get paid for it, but not actually need to go to school [...] So i didn't do math, didn't do higher math, I only did biology.

K: Did you ever consider going into more technical studies?

Mo: Well CDT is building selves and woodworking, and I didn't do computing either. what did i do?

K: when you were a child did you build stuff?

Mo: Lego, so much Lego and computers, we didn't have a television but we did have computers, I have spend all my life with computers, as soon as the Internet came out we got it. I have played loads of computer games, loads but no TV.

I am very computer literate, like I am happy around them, and I enjoy that side of it, making things side of it, but I don't actually like computer, don't feel inspired by them, I don't know why I feel I did fine in the science subjects, I hat4ed math with passion, I passed it, don't know how but I did it. I think That form an early age I was pretty set with what I wanted to do.

K: Did you feel encourage towards the more techie stuff or the other way around?

Mo: Actually my folks did not discourage me from doing anything as far as I was progressing towards anything. I was getting the impression that they were happy, but I guess I never tried to do something that they would disagree with.

K: I think that is OK in the side of defining a background. obviously working with 3D printers is quite technical, that is why I am asking this sort of questions, trying to understand how technically inclined you are.

So would you describe yourself as someone who likes to Tinker?

Mo: Yeah... turns out I like robots a lot, which I really didn't think I would. but, no, funnily enough when I was deciding I did film , for my first year of university, and then I was hating it. I want to create something physical. And so that is the reason I decided to go to textiles because I wanted to make something, even though is technical, the way it is technical, and the actual skill of understanding the process and to be able to make each part of it, so you just don't make a drawing, you need to take it all the way into making the fabric and that technical side of it, so the physical side of making art work, no just he conceptual side of it, has always interested me.

So machines, this is the first time, I have used the laser cutting at uni, but that is like understanding a path works on a computer, so it wasn't a great deal to use the laser cutter. I think I just really like 3D printing, I like making to see what it can do, I really love the 3D modelling of it, if that makes sense.

K: Do you see a relationship/similarity between textile machinery and 3D printing.

M: No not really, actually the only machine in textiles that you make one person rather that a comercial production, would be the exposure (check with her) and is not really a machine is more like a light box.

M: but the things that are the same... I guess is persevering with it, with what you are doing and not just wanting and instant result and understanding that the process is as important as a part of the work as, the drawing for example, or the conception of the idea, and then as for any making process waiting for it to mess up. and technically recording what you are doing, but process wise is completely different; textiles is mainly a 2d technique and scale wise as well.

K: have you ever felt excluded from tinkering or working with technology?

M: Not really, no. I guess my understanding of how computers work makes a lot of things quite open, I suppose money wise it can be very difficult to have access. Specially if not in an university setting, which has been really handy here, but if there is way... there is a way...I have always found ways of getting a hold of laser cutters, I don't think that socially I have ever felt excluded from the understanding of things. But practically available to me... once you are not part of the university, unless you have unlimited money...

K: Have you ever participated or been part of a group of technologist/hacklab...

M:I always liked the idea of joining, makeworks , hacklab and maklab, I follow them, instead of looking at them from afar, but is the amount of money that it costs... I would have to know that I had to be really committing. I suppose that now, after this collaboration I know how to... because I could go and say hey I know how to do this, but definitely before it would have not happened, so maybe at some stage in the future I could, but I would have to narrow down the stuff I want to do [...50 pounds a month...] And then the hours are weird, to join the Edinburgh one you need to go to the open days and they only have a few a year... So normally I have a deadline and need to get through stuff as fast as possible.

K: Do you think your gender has influenced the way your opportunities have been shaped?

M: Its annoying being a girl and doing textiles that for sure, I guess I never thought about it and the kind of work I make isn't particularly feminist. Up until now I never made thing that relates to my gender at all. And I guess it is not really sticking to me; I am a white mid 20 straight woman, which just got on with everything. It is annoying because everyone who does textiles is a girl, because it was all girls it was very intense, in my life many of my friends are males... but in uni we never got that male perspective or a different way of creating the work. It almost the same as in fashion, but there e is more balanced. I don't know if it that of seeing the grass greener on the other side, but I always felt that I f I was a man I could have been more successful, have more choice, somehow people would see it that is different to be a male textile artist, and people could be more interested. But might just be some wishful thinking.

K: if you look at 3D printing in comparison to textiles, can you see some relation.

M: I did begin doing some research on what was happening with 3D printing. All of the kit is aimed at men, coming out of America and very commercial and they know what is going to sell and who will have the money to buy all this expensive kit. And then the annoying/advertising/ marketing people making it look like that silly makerbot, with the lights and the chrome, its really weird, and the way they portray that woman from MIT, don't remember the name, //Neri Oxman// who can make this amazing things. I can picture the article and the magazine, I think if you look at the people who are making the machines, the people who is trying to make money out of 3D printing know why, they know their target market and that there is why. But if you look at the 3D printing communities, online communities, shapeways and so on... is much more gender balanced, is more anonymous as well, so it doesn't matter who is tipping behind the computer, you just see what they have made or they have a funny avatar name, that doesn't indicate whether they are males or females. And then it comes that it doesn't really matter, and surely one day people that does marketing will look at this and say, hang on it... what are we doing?

K: Have you ever felt discouraged by the marketing?

M: Well I am behind a machine, so not really. Although I am sure it is a boys club in some ways, but I guess I have been very lucky, in that all the 3D printing I have ever done ever has been with Diego, here, actually, no, Andy, the guy who owns my flat has a massive like CNC machine in his studio and he has a 3D printer, and we have spoken about it as well, so I guess I had a really balance view given to me and lots of the people that I meet at ECA are both men and women, and loads of people that I met through Diego, in the chiasmas and stuff, there was a good balance between men and women. So I slightly feel like this is what University is about, some kind of liberal bubble where everybody is quite happy with each other and everyone is trying to make nice work and get on with it. I have never tried to commercially print anything because I have not gone out to make money to really experience the real world of setting of having to pay to do it. Because I have been doing it as part of this academic collaboration I've kind of bypass all that, so maybe I will but for now not.

K: Gender and technology, Do you think that women and girls are more likely to be excluded?

M; I think I am a special case having said all that, like from my upbringing, from my own personal experience that is how it has been, but definitely through people who doesn't have such a liberal techie parents, maybe wouldn't occur to people to introduce their kids to this. And definitely, not sure, now if its better, because I did not do this in School. Don't know if there is a change in the formative years. So I didn't know if it would interest me till I knew, I did not think I would take on 3D printing till it was introduced to me, at that point I ve already done me whole degree and I liked to make things and this is how...

K: I want to talk a little bit a bout the collaboration and how you define yourself as an artist. Can you tell me what is like to be a textile artist? is it how do you define yourself?

M: I went through university, so you have to learn an skill, some of my friends went into degrees. but I wanted to learn to make something, a tangible skill. So it have changed a lot since I left school, it was like yes I am a textile artist and I do textiles for constructive photography, so make the textile things, and then I photograph them, so in the end the piece of work was the photograph of the moment. And then slowly through the last 3 years its been so hard, because textiles are very hard to make, and as a society we don't value textiles, the way we consume them is in a way that it isn't valued. Then everybody has a camera, fine art photography is one of the hardest things to get them valued, because people don't value photography either, so putting those two expensive things together and coming out with the most expensive work that nobody would buy... it took me a long time... to realise... what am I doing? Shit now because people don't value textile, I find my self at a war in which I am like do I stick with it? and go NO, this is the work I make, this is what I am trained to make and this is what I do, or whether I am an artist, because now I make work in many different ways as well, but I think my background will always be at the heart of it.

K: So you define yourself as an artist...

M: well, seeing a pathway and moving towards that direction

K: SO is collaboration important in your work? or do you mainly work alone?

M: Its kind of a combination really, I think some of the most successful work has been part of a collaboration, apart from this collaboration, with Diego, I made work with a poet for an exhibition for the Edinburgh printmakers, the idea was that they paired printmakers and poets and that worked because it was very interesting conceptually. And my writing got a lot better working with Sam, but I would say half of my work, not sure, because I make so many different types of work, which Is something I am trying to stop, because I find it very exhausting, but I pick up a lot of graphic design, photography commissions and I get paid for those, because I don't get paid for my own projects; the textile sculpture stuff and so I make that for myself and entirely by myself. Then I guess commissions, I collaborate with some other people but is mainly design and then there is this stuff with Diego, which has been the longest running one. So, to answer the question; half and half.

K: Have you collaborated along more technical disciplines? Core sciences or humanities? Chemistry?or something else... have you considered it?

M: I have, I have projects in my mind and things that I would like to try. Definitely to do in the way we colors textiles, I have a friend that is a gardener and we were talking about creating some work. And then the idea of collaboration with scientist is good. But its quite restrictive in the way that they are massively oversubscribed and then they ask for a certain level of success to accept the artist in, and you have to be able to proof that you have done it before. So I think that what will happen hopefully, is that I will get an idea and then meet an scientist. And it would be a personal development thing. Although I just remember the work that I am making with Diego... I went for a PhD interview in Nottingham, for this thing, but I didn't get it, my friend who is doing her sociology PhD there, they are doing stuff with the human Genome project and that is science. And her idea is to look at the ethics,and and so my work tights in a bit into that, but it has not started yet. So I am open to collaborate but has not happened yet.

K: SO the follow up question to that is; What is important in a collaboration for you, or what makes a collaboration successful for you?

M: Probably a few things, that I get on with the person, willingness to discuss things, is not just about getting on, have different point of views, have an interesting conversational back and forth because then you are learning, I supposed I am quiet focus in where I like to go and ambitious, and don't have a lot of time, so I am trying to think about some collaborations that I have started that have not got anywhere... I have probably forgotten about them. But the idea that I learn something about a collaboration that is going to, maybe later on on my career, maybe do something right or form part of the knowledge that I am getting, but the definitely at the moment maybe because I feel like I am just starting and is going to be a lifelong thing that I do, ideally every time that I make work I try to make something new, that challenges what I think of as the work that I make ... anything really... technical ability, the way I see the world, things I know about... just learning. But I think is nice to work with people and see that the things you have learnt are interesting to other people, the way I see the world is interesting to other person and that they want to know about my skills as well, so I am learning, they are learning; we make something through that learning and I think that if a collaboration didn't have that, it wouldn't be worth doing.

K: So you cant really think of any unsuccessful collaborations?

M: I am sure I have... I went to an interview at the Edinburgh archaeologists archive, as part as a residency, and everything was kind of OK, and it failed because I couldn't really conceptualize what was going to come out of it. So I didn't do the proposal, they wanted me to do everything, they had no specific idea. I am sure, thing s like people not turning up... or just not putting in loads of energy.

K: So maybe not having some common ground... the archive was a bit far from your discipline...

M: yeah like having difficulty finding what... so in this case it was like come with something but not much back and forth or there was but not a fluent communication. So I had to do all of it... so not very engaging.

K: If you compare that with the collaboration with Diego, how would you compare that with the beginning with Diego?

M: When I met Diego, I was showing work at knockengorroch. that was a logistical disaster. And I was also working in the cafe, and I met Diego... And I don't remember, he was like yeah... he wanted to have artist to talk about emerging technologies and I think that it was 2 years ago... he had not decided if it was 3D printing, I certainly remember, because I think he was thinking it was new technology... and since then it has kind of honed down. And usually I am totally up for anything if I get 5 minutes... and I got his card... and then maybe he emailed, gmail saves everything.

But I remember that the first time we met about it, He brought me a 3D printed bicycle, and he asked, do you know anything about it? And I did because Andy had one in the house.

He'd printed some things, and always thought that it was cool.

But yeah with Diego it was very engaging, I remember we had a very good chat and then he was like; do you want to do something? I am pretty sure that if you ask everyone... no one is going to say no. Specially as an artist.. it was just like yeah!

K: What was it that caught your interest from the start?

I guess the idea of researching of something that is quite new. And for me the idea of learning something new. The idea that it could be something, because it is such a new technology, like that feeling of what would it have been if you have been around when that people that discovered cubism... or if you were one of the ones that was making stuff from the beginning with any kind of wave of things... that feeling... none has done this before. So the feeling of doing something new is very important for an artist.

So the idea that textiles and 3D printing has not been put together before, and I think Diego and I talked about it and I think that having the perspective of not knowing anything about it. So i didn't know what was possible either, so why talked about... what would you do with this? and I was like... lets try this and that.... SO it was the idea of making something new suppose. but also the idea that I feel like I am in a unique position, if I had not met Diego I would have never done it or I would have not had the idea to put the two things together and then spend the money somehow. Because he came and said look it is a 3D printer lets do some stuff... and he had time and was interest I guess the academic environment was his job, but we could just sit for hours and hours with the printers.

So I guess those two things come together, the idea that collaboration is when the practices of two people meet, maybe not similar but different, and Diego and me we have some similarities and the way we have gone about our careers is very different, but because we came from two very different perspectives that bend diagram meet in the middle, where else in the world are two other people with the same background as us are meeting to make the stuff, then is more likely that you are making something new and innovative i guess.

K: So you mention that, you didn't know a lot about 3D printing before, but you had a house mate...

M: I have seen one, he had one... a rep rap and he, Andy he works for the circus, and he is away on tour as a musician, 6 to 9 months a year... when he comes back he doesn't work, he doesn't need to. And all he does is play with machines, that is it. Just as I met Diego I just moved in to the house, so I just kind of met Andy, all of this happened in a month or two months, so I had been one just for the time just before meeting Diego. And I did not know anything about 3D modeling, which for me is a huge part of the process, again because is being able to do every stage of the process, instead of just getting someone to do it for you. I definitely I had never seen or used any 3D modeling software and had no idea of how you got from the idea to the final thing. I understood that it was like photoshop or illustrator, but never seen it before.

K: So before you met Diego, have you ever considered what 3D printing was about? was there a connection with textiles?

M: No, I have learnt as much as you can reading the news or distractify or whatever... or post in facebook... I would have know as much as that. At that stage I was just year after uni so I was still considering the role of textiles in my career.

K: So was it a difficult choice then?

M; no, I think no, I don't usually make choices, stuff just happens... so it was like yeah, why not it sounded fun, I had the time. Although I must say it was quite a long time between the first meeting and when we actually started making anything, that could be considered any real work, almost a year but not so long. maybe 6 months.

K: Why do you think it took so long to get it started?

M; I was doing some other work, and started the residency in ECA September 2013, and I met Diego in May/April, so we had one meeting in that summer time and I was applying for the residency and working in music festivals so I was away most of the summer and making things, and then... So I think it was probably scheduling issues more than anything else,

K: did you ever feel like uncomfortable, or like a lack of confidence, like what is this technology? is this something I can use?

M: Well funny enough is not the machine, is the controlling part of it, it took me a long time to get to grips with the software, mainly I couldn't get it. Because I started with tinkercad . And it was the right choice to begin with I would probably use that to introduce other people. Because I use illustrator and photoshop. There is an specific mind set for tinkercad. Tinkercad was too dumbed down that it frustrated me... it didn't do all the things that I wanted it to do. Because it doesn't work like the programs I use... It took me ages to get to it and if you cant do that part you cant innovate and design with the machine in mind, which is what I got now because everything you print will look boring. Cause it can only do what you can put into it, so for the first things we tried it was interesting but couldn't see and aesthetic in it, it is very... also the filament is so horrifying look. So we made some little ring things that clipped the fabrics, and Diego was like, this is very interesting we should make the things and I was looking at the things without realizing what it was about... but it was because I couldn't realise my aesthetic idea of what I wanted things to look like. So there was one day I came in and I though I cant do this, this software is too hard, I don't want to, I couldn't do it. And then he was like... show me what you want to do, and then I did it... and in ten minutes I got there, I started making my things, and made 6 design or something. That summer I was making the work for the poet as well. Too many things.

K: Can you summarize? what were you doing when you were meeting?

M: a lot of talking about how we could put textile and 3D printing, not the why or for what but mainly about how, and it was mainly fiddling... I was bringing new pieces of fabric, and try it and then guessing what could work better. Quite early we realized that with the printrbot we could do it because of the width of the nozzle and the way it is very open. and how we could go through every stage and we spend a lot of time into working all the steps and the bullying me into using the software properly. We used to talk a lot around 3D printing and I learnt a lot about things and Diego would show me stuff and then I would find things and talk about stuff. And we did talked about

what would it be used for. And I was and still am against going into anything to do with fashion because as an industry I don't agree with it. I don't care. It doesn't matter with 3D printing, even though people thinks it is really fast, it is not at all, it all only makes tinny stuff and is so labour intensive for something that is plastic, that people don't value. Why are you making this to be worn one season and then sack. so no, nothing to do with fashion. Even though every time someone sees i, because is textiles they relate it to fashion. so we kind of agreed to leave it and make samples so people could look at and think about different things. So we could encourage a conversation.

K: So what would you say it was the most exciting aspect of collaborating with Diego?

M: Learning to 3D print or this new things and other machine, as well as the feeling of doing something that has not been done before, we were researching something new, and as work I was making so it was different too, and people loves 3D printing, so everyone was interested. Also I was doing the residency in Textiles and it wasn't going well, so I spent most of the time working here. And textile it just didn't work. I wasn't able to realise the type of work I wanted to do there, as a creative environment didn't work for me, I ended up doing a huge comision rather than doing my own work. But here it was like a colleague, it wasn't top down, Diego and I will sit and make stuff and it was fun, also because he was upstairs at one point we had loads of space and it felt like it was us and the printers. And as well Diego is very enthusiastic and that is good when you work with someone who has so much energy... it is like yeah! lets do this! you want to just make the work.

K: so when you were learning to use the 3D printer, did you discover something new about yourself or your work?

M: definitely about the work that I make, then Diego got it into that conference in Falmouth, so then we had something to work towards and that was great, then you have a purpose in there so you are not just messing around. You are like ooo we are going to exhibit this so you push yours self to bring more interesting things and to show it to people and I had some few ideas. but definitely adding it to, as I said before textiles is 2D, yes the work becomes 3D in that that exists, my work is getting a 2d image into textiles and distorting it naturally in itself. but is not the same. Having to think in 3D dimensions and fully realise something rather than a flat image has helped my other work. because I can now think in more easily in 3Dimensions, its definitely, the work I make with 3D printers now is more conceptual, that was one of the problems with my work, is more design or art work? but I couldn't do what I do now if I had not gone through the learning and also I guess, slightly aside from the 3D printing, I am learning what an academic art or design route would be. Like Diego, I did one of the workshops and then I helped run one of them, it was interesting to see the research side of it.

K: great, were there any negatives, or anything that could have been improved through the collaboration?

M: The ECA itself was a bit annoying, so just as we found that we were going to make work for the Falmouth conference. All makers now, Diego had to move from the office in the top to here, which is good for writing. but not so much for working or having a room we knew we could always go into. I guess in some ways it meant that we were complacent at the time, but it was sometimes irritating that we had to find rooms to do the printing, and sometimes it was fine and some it wasn't fine. it had nothing to do anything with Diego at all, it was obviously University, it was his work going on for ages, they should be on the side of the people who was making the work.

K: so what would you say Diego might have learnt from you?

M: Hopefully, a lot of stuff? maybe issues with someone trying to learn the 3D software, I don't know, I have never asked him. probably a bit more about how textiles works, or at least about the aspirations of an artist trying to make work. I definitely harp on on how hard it is because I have to work as a waitress as well. I am sure Diego gets that it is annoying. But that idea of what an artist wants of the tools and what it could be used for and the difficulties, if you are technically capable as Diego is, working with someone that has no idea of what they are doing at all, and showing them through the whole process, form never seen a 3D printer, to now you can use it by yourself. Now I am independent and I am happily printing away by myself. So if he were to ever do that again, he would know for all the people and help to understand and explain and I guess he has seen the direction the technology is headed in. A lot of it was just my designs, but I could have not made it without Diego and he has been talking with people and see what the reaction is, so I guess in research terms you have a thing to talk around rather than just to ask questions. and then I guess it opens up for the research questions.

K: what do you think are the most important research findings in this area?

M: That I think, it is unfortunately our technique. The idea behind the technique is very interesting and what it can be used for, maybe as a technique to make things I am not the person to take it forward, the idea that you can have living or amalgamated hinges and things, and I hope Diego meets someone who is more interested in that direction, Is not that I am not interested, but I am focused in the most conceptual side of it.

M:Why are they making them into black boxes? but the work we have made we could have not done with the ones with doors. And that kind of magic lure. Why are they doing that? and why are they storing people making if they do that. And what are they stopping people making if they do that?

K: So it is almost like when the technology becomes user friendly...

M: hindering itself by, because there is a difference between user friendly and like a tool, or a basic tool, or I guess trying to make it into something that is not a design, is not an amazing machine that thinks by itself and design things, it needs to be as basic and useful as possible, so you can do absolutely anything, like you can with any other piece of equipment pretty much. I mean it always will have its limitations. But the more avenues you close of the more things you cant do with it. which seems silly, it prints plastic, little plastic models. If people things they can do more things with it they should keep them. They make more money if people thinks its magic.

K: Maybe is less daunting when you hide the cables away... just a button. So if you compare desktop printers...

M: yeah I guess that is it... what can you do with a desktop printers ? unless you understand... The thing I have been wanting to do with them is change the cartridges with dyes which then you transfer into polyester and nylon and plastic filament fabrics, but there is not much you can do with a desktop printer, maybe that is the product of having made them as easy as possible.

K: is there something you would like to add?

M: Well the work that we made started with trapping fabric between prints and then growing objects out of bits of fabric and I still feel that there is work to be made with that idea. Not sure what it is yet. It is very slow, I am sure, I have loads of sketch books of things to do. and then we had a break... we had been very busy. So over Christmas I had the printer and I experienced with other things trapping other stuff in the prints. So it was totally different and it didn't go with he rest, but from that idea... evolved the idea of what I am making now, and is still part of the collaboration, although is more in the line of my own work and I have become more confident with the software and machine through perseverance and time. So i made this more conceptual things, so in terms of the collaboration we have not sit down together to make more work, although I want to make more. So try to make to move forward conceptually because the work itself is so slow and its not so really appropriate so just gluing the pieces together in the end is probably just as effective. So from the design point of view, so there is probably an output where it makes sense to almagamate the fabric and the print for a hinge or with kevlar and the kind of the safety things... there is something... but I think somebody else with expertise and the head on to that would enjoy it, but I have been working on why would you do it and what meaning does it give if you 3D printing... why? to make objects that you could only have made through 3D printing, so they could have not been made by any other way and that is then self justifying, so you could have not done it just by sticking to bits together.

K: How would you describe Diego as a collaborator?

M: Enthusiastic, like so much energy for just one human being, even when he says he is tired he looks like he is ready to go for a run. Definitely very encouraging, if you think about how long it took me to get to the point where i could make work with the machine... he obviously show something in the work... and knew there was somewhere where it could go that maybe it coins out and good teacher, I have got to the point in which I can use... pretty much any printer... pretty much like an ideal collaborator, he spilled time on to it. I have never felt that there was more on either side... we both put in together.

K: and do you feel more confident.

M: yes want one... but they are so expensive, 300 pounds for a cheap one... ... especially when I can come and borrow one for free. Not sure how I am going to feel when it is not going to be possible anymore. For sure now I would be happy to go out, he did the ultimaker bit and I did the printrbot because we use a different technique with each of them.

K: 2 or 3 more questions. DO you think you will do more 3D printing stuff...?

M: I think I would like to continue to do more 3D printing for a few reasons, one being that people loves 3D printers, and it is hard being an artists, and it is silly but having a hook and showing that I do a lot of different things. I can see work that I am doing right now... 3D printers print in the same way that a spider makes a wave... so it is one continuous filament as long as you are making, so you make something completely hollow and just trapped by one line of 3D printing. So I am making this for my boyfriend, I have always been obsessed with the idea of time traveling rough object and the idea that something will take you somewhere and you have all of this things trapped inside a thing. And the stuff we don't remember, I have loads of time capsules from when I was a kid, I made so many... I love that idea and think it is a very human thing to want to trap time and not loose memories. So I wrote a really long piece of paper wounded it up and wrote a letter remembering this things and putting it inside an object that I 3D modeled, practicing filling some with red wool, but the printerbot wouldn't print without infill... just doesn't like it... it would print things in different ways. So went to to Germany for the residency I brought this... and they are clear so you can see there are things. And I can see where this work could go... for instance the human Genome project... so you create an object and the only way to get the information is to smash the object and the more beautiful you make the object and appealing the less likely the people is to smash it or maybe not, is that idea that you can physically interact with your data... to make you really understand, so maybe opening an envelope is not enough... but really do you want to know what is in that or not? there is a lot of research and art, and I can see a lot of things in that and 3D printing, is there another way to make that? because it makes it so beautiful. So yeah definitely, but I will always keep doing more things, and hope to work with Diego when he finished his PhD, but I know we will have another exhibition to make work for.

K: So you mentioned like the effort that you put into learning the software, would you say that 3D printing is challenging some of the traditional arts or skills that craftspeople and artist require, or is it the case that you have to be digitally...?

M: It is an interesting one, I think that 3D printing unfortunately has a lot of stigma attached... people know more about what people say about 3D printing, that they actually do about the process and what it its and how it works and this is aided by the media coverage, like they show things and explain what extrusion is and the image will show something that has been laser sintered. So there is a lot of...ooo that is not hand made and I know this is something Diego has been researching... What is handmade... And I would maintain that the things I make with the 3D printers are handmade. Its not different from sitting with a lathe where you are taking things away.. you have to know how it works, and now is just a digital way... and learning to use the software has been a journey, I am still on the journey I still don't understand rhino at all, like a lot of more technical things. But is that different to learning how to physically carve something? I still think that in some ways I would be better molding something out of clay than with the software and I think there always be some kind of intuition thing, but there is a barrier... I am probably one of the best people to ask... because I am so used to computers and always have been and using a mouse is quite accurate for me now, but is not the same, so what is the purpose, so it would be interesting to see how it progresses, but I think is and understanding of the thing that would be the difficulty... how people perceive it is really getting people to really understand what it is before they give it a label.

K: and do you think you might have a responsibility or a purpose in life to ...

M: help people understand? hehehe I think that with the work, I hop that my work will challenge that, idea that is not handmade, in that I really try to design for the material rather than against the material because I don't like plastic particularly, I try to see something more in the plastic rather than a printed model thing, trying to make it beautiful in itself. I hope that then people will see that and think how was that made and then conceptualizing how it makes, and maybe that idea that robots have souls... we are all nature and even the robotic things that we make, its so easy to anthromorphize, they do react differently to things and adding a conceptual element to the machine or part of it would hopefully make people think again about that idea that I just press the button and printed something for me, because we are disrupting the print and trying to add things and make more than just a model thing.

K: what role do you think people like you or artist might play in maybe explaining on what 3D printing is or influencing the direction of technology

M: I am not sure how, all it takes one this is colossal... people are looking at it... I think that the artist role is the challenge. Our role would be as with anything you don't believes is true... to challenge it through the work that you make, and speak with the people, whether or not we influence will actually influence wether they will end up making this boxes that press print and thigns like that. I guess it take sone company to see that there is not the only way. So they say this one is fro thepeople who wants to... But just as an artist I am going to be able to do that... it feels like unachieveible, because of the vastness of the indutry.. so you dont knwo you can do it in your own sphere of influence.

K:Any more comments

M: maybe figure out a different way of exhibiting...

Jennifer Gray Interview

0:00.0 - 0:22.9 recording agreement

0:22.9 - 0:34.5 It is an interesting line you have taken with your research. could you further your sort of are for me, in terms of what research areas of craft you are looking at, or is it just ceramics?

0:34.5 - 1:43.0 I should probably at some point decide, for now I am trying to keep it open, for various reasons, one of them is; that I organised a workshop with some of my colleagues, six months ago. basically, it was 2 full days; 2 afternoons and one full day. We had 3 craft practitioners; stonemason, silversmith and jeweller and a ceramist. Then the rest, seven students, from across design disciplines from ECA. The workshop was about learning different process or methods around 3D printing and then 3D printing objects. I have been basically following the lines of the things that came out as standing points out of that: First; the technology as it is has no use for a practitioner...

1:43.0 - 1:44.0 Umm, I know.

1:44.0 - 1:50.8 other than making models and prototypes, very quick, but then you must have the digital skills.

1:50.8 - 3:17.0 Yeah, for me is stationary process using this and did have to scale (Skill up?) myself up (talking about the horn project) I mean that is what I used for my masters. The thing is a like the idea, I like that I don't like it, it has a terrible aesthetic. when it comes out is not a kit, is not a prototype, is not a finished piece. You know maybe in the future they will be... I mean even now, I was in the design museum and they had the Futures Now exhibition, and they had these extruded wonderful pieces of furniture, they had... you know there is a lot going on, but for a practitioner, that is like a photographer, you know suddenly the digital age happened, is like; o shit, you must unlearn everything, and then you know they are () to keep up with their time. I was an adult in later life going for a Masters, so I was quite skilled up with, you know, jewellery -silversmithing techniques, I did a lot of carving and wax and casting, so model carving was a nice technique, but I felt it was a bit of a shame to just forget it, because of; "Wow" there is all this new technology, forget everything you learnt and jump in to that.

3:15.9 - 3:36.9 So, I found programs that were not actually for... you know I have used Rhino in the past, I always use that you know, is good for accurate modelling, but still a totally different defection for the carving and the hand zone, you know those skills. So, I found this software called Zbrush, it is used by animators and they can model characters and then render them and then render them. So, I found it was very intuitive, o well I can use it intuitively. I can just use the scene way, and if was a person I was carving I would have images of them in the room, and instead of carving everything by wax, I would carve it in a digital ball of wax using a wacom tablet, it works wonderfully. So, I rapid prototype then I cast from this, the prototype is still an ugly material; is a prototype, then I cast in in metals in stone... all sorts if that. It's been good, you know, for me it has been a huge change than I am able to use both, I think it is just a case of collecting skills. Like another project I am working in now; the national Museum of Scotland and some archaeologists there. I must make these objects, they want me to make this artefacts that have not survived, but they know they exist through writing, so I am using and dipping in to my old techniques and using the digital, you use them in different combinations.

5:30.2 - 6:03.1   It's been a very long answer to that question... I think is good to have both and use them as you see fit. Because I see some people jumping into the digital stuff and that is overused, but then again, often they will go and do something else that is interesting, so... Do you believe they can be used together? or is a case of building new machines that can extrude clay...in terms of materials...?

6:03.1 - 7:25.5   These are mainly my two lines of action. One of them is identifying processes that would be relevant for practitioners, for instance, one of the things I am doing is scanning objects or stones to create a stone setting. That, would speed up the process of creating a necklace or anything... raises many questions, if the piece is going to be the stone setting, the the piece is going to be digitally created not crafted, unless you understand digitally created as crafted. Then the other thing I am trying to do is finding alternative ways in which the machinery could be modified... so it would be more relevant to different participants. the workshop the craft practitioners show some use of it but they did not identify as part of their practice, as well they were mature.

7:25.5 - 8:25.0   Old? So, that is a point, you know people are stuck in their ways and they are used to work with certain technique and they are real experts, if this new technology slows their process then is not good, but there needs to be the magic point for me, the important point for me is the scaling of things, up and down, even for that reason alone. The fact I can do that with my digital carvings makes it worthwhile. and I can do so much now that I could not do in the past, it means that market is open I can make faster, and is not as elitist, the same carving can be repeated smaller or bigger, before I would say, well you must pay for the whole thing to be done again. It makes the process faster.

8:25.0 - 8:31.4 So how are you using the printers?

8:31.4 - 10:18.7 The printers, well I use a mixture of different machinery; it could be a mixture milling out from wood, so I have my digital carving but I want the piece to be wooden, I will use a 4-axis miller or wood miller a cutting device that will clear the rough first and then the fine details. I only use manual settings and the carved wood still looks like one of my carvings even though it has been digitally done. You can use all this benefits for you to carve symmetrically, but then you lose the feeling of something that is handmade. The milling out really looks like it has been carved from wood because I use very fine tools. Fruit wood. pear wood. I additionally use printing from a large scale from Zcorp, plaster and then coat it with lacer, so I use fibre glass or house hold filler, and then lacer to slot things together and then take a mild and then cast it in the real material, but the object is up to a millimetre accurate.

I use high resolution resin to make models and carvings that I put together in another program called magics, which is an engineering program that can deal with high resolution files, where other software's cant. And then I print them out, make silicon molds or wax and then cast them in any other material. I have done casting before so there is just another stage in there. For example, there was this commission last year; silver drinking vessels that were held together by wooden core, but it had to be exact, they had to fit exact without shaking. They were oval shapes, it is easier to make spheres, additionally they had to have carvings in them. So, I made a tool, an egg tool to put in the lathe, and using digital cutting you could put silver into that, and it was perfect. Not only can you make objects but you can make tools as well.

I have a very good relationship with Rapid Form in the RCA, I still use them to do all my rapid prototyping, because they are friends as well and they are quite up for trying new things. They were saying... we have this guy with a printer that can print in steel. Then I said I will make a tool. So, I made a pressing tool, it had faces on it that would be very hard to make in any other way. It became a high tone pressing tool, so you could press all those objects with it.

13:25.7 - 13:33.1 I was about to ask you, where were you making most of the things... because we don't have this machinery here.

13:33.1 - 14:21.6 I am going to London, I am in London every month, I go there a lot, there seems to be much more going on. Although I teach in Edinburgh I feel that sometimes my skills are not utilised, because they are not equipped yet for this kind of work. I can teach all the older and traditional techniques. Whereas some other universities are more advances.

14:21.6 - 14:54.5 Well, I think they are trying to move forward, I was successful on an application to set a Minilab here and I will be running workshops. It is going to be low level printers. They are easy to use and they cannot break you hand if you put it in the wrong place.

14:55.4 - 15:03.5 I know, that is the problem with some of the milling machines is that they can destroy itself and its worth thousands of pounds.

15:03.5 - 15:10.0 The most expensive thing about this machine is the tip and is about 50 pounds.

15:10.0 - 15:29.5 Oh really, this is it! I was thinking of potentially buying a RepRap and then putting it together, but then I though, umm, it is like the earliest model of the iphone or something like that is going to improve in a couple of years, so I might as well buy it when it is better and cheaper.

15:29.5 - 15:40.9 That is a rep rap, the project got one for me, I can tell you already there is a big difference in between the two (Ultimaker and RepRap) and is not even finished.

15:40.9 - 15:59.9 I went to a seminar in London, these guys were presenting this and talking about it and it is a good solid concept.

15:59.4 - 16:02.2 DZ- Yeah but it is very hard to use or maintain.

16:02.2 - 16:04.9 Oh, is it, Hard to maintain?

16:04.8 - 16:16.1 Apparently yeah, the structure is quite shaky, or gets shaky with time and use, I don’t know yet. I must get used to use it Mainly the reviews said so...

16:16.1 - 16:19.7 Can not they just RP themselves again, and then you get a new one...

16:19.7 - 16:22.0 Well kind of... heheh

16:22.0 - 16:25.2 Self-replication ever maybe...

16:25.2 - 16:30.7 We are not there yet. There is one that can self-replicate up to 80%

16:30.7 - 16:34.4 Off course you need some of the steel tools

16:34.3 - 16:57.5 Well that one is not using steel, it is in an early stage, most of it is plastic. It is interesting one, but is slightly different from the others. May I ask you... how old are you?

16:57.5 - 17:55.2 I am about to turn 30. [birthday talk]

17:55.2 - 17:57.3 So, when did you do your masters?

17:57.3 - 20:52.7 Masters, I did my undergraduate BA in Glasgow school of Art, 2006, Silversmithing and Jewellery. To be honest back on those days silicon's and plastics... we weren't good... I wanted to use such materials, but they would either be too toxic or the silicon wasn't good enough. And I did do a lot of experimentation with plastics and castable rubbers. but they were too unpredictable and sometimes they would set to be too hard, sometimes they would be too rubbery and soft. There was no, and I just noticed I don't know if it is my awareness more and I am able to get better contacts, with tradesmen, and you know I was younger and I didn't do as much exploring as I do now. There was just not such as good materials available. So, I would do a lot more traditional in carving and casting in metal and [] maybe in plastic a bit, but that was as much as I would use. This would be vulcanised or rubber. If we wanted to make moulds we would vulcanise the rubber... It would be quite a heavy process, and great, wonderful. But now you don't need that much kit.

[Companies that she would use]

Then I worked as a Designer/Maker for a few years. And thought for a few years.

[Places]

Then I quitted my job and went to the RSA to do the Masters in 2010-2012.

20:52.7 - 22:03.1 I am still working now, while teaching. I see 70/30 My own work and teaching.

Most of my business s in London, so I need to go there frequently.

I think some curiosities have been planted on me, by being surrounded with something that you want to keep up with.

I supposed for students as well, you know you want to scale yourself so you can help people, but for my own reason, you know learning to improve my own practice. You know I struggle to see if I am a designer or an artist, so I like problem solving, looking for the most efficient or best solutions specially if you are going to sell it.

22:03.1 - 22:12.9 When did that perception of yourself strike you? Was t during your undergrad or later?

22:12.8 - 24:00.3 I suppose it has always been there. I suppose I am feeling multidiscipline, and what I make crosses a few disciplines. I would much of a journey, I have an interest in design and at that age I was doing jewellery, but it could have been another subject. But I loved the small sculptural form you could make, so it made sense to do that. I learnt to [gather] and to be challenge, so I do like to have a commercial outlet for it, not just making for myself. You know littering the world with things which aren't used. So, I would do sometimes either the most functional things, they are elaborating or they are luxury goods I suppose. But at least they have an application or a purpose. So, it could be anything [] and working with the archaeologist and making/remaking this objects of antiquity or artefacts.

The end Product doesn't matter, I am process driven I suppose, and that could be within the research and the making. So, when something new comes up, I go ouch how could that be used? Sometimes I could use Or I could get a way to use it, but other times It would be like... um ok I learnt that for my work.

24:00.3 - 24:15.2 What about your interest? is it process driven? Or would you like to see the world embracing new technologies and making them easier for people to use?

24:15.1 - 25:50.9 Well, I have tried to get to an undefined position for my PhD. At the beginning I said, yeah, 3D printers, that is the future. Then I realised that everyone was saying the same thing, then I said, ok... what happens when everyone starts saying the same thing? That is that sometimes it goes and sometimes it doesn't, and sometimes it crashes fatally.

So, I tried to move away from that, I said let's see, let's see what happens... understand it and work around it.

Not just technology, everything. [anthropology]

I think that it might have a use, sometimes I get responses of people saying, ah, this is like the microwave. When it came out people, everyone thought that everyone would stop cooking.

The same happened with desktop publishing, in the 80s, everyone though that home printers would finish the printing companies and event he crafts around printing.

It did pose a challenge.

26:07.5 - 29:32.8 I think it has its place, when 3D printing first started being used maybe people thought about that, wow, maybe the world thought that it might change a wee bit. But maybe the technology for 3D printing would be use in loads of different areas, like you know they buy a toaster, but the handle is not right, you know they can get the model online, 3D prints the part to go back on it.

I think in terms of that is good and it doesn't need to be the highest quality, I t can just be a shity plastic. It can make your toaster work and you don't need to buy a new one... it's great.

I think there is a fun side to it as well, people printing toys and fun things, it will be quite faddy.

In the imperial college, they were developing this scanners that go around your body and in 30 seconds they can scan a person and can print out you own toy.

I think industry will make them work in a specialised way for what they need, for wax building, for jewellery building, you know that is great for casting. You can put the sprouts and the channels for the metal. They can be high precision engineering. I think it will separate into loads of different disciplines. And I think, for home, I can not really imagine, I am not nervous as a maker as a designer that my skills and my position is going to be totally redundant because people at home are [or are not check with some else] their own accessories.

I think there is a lot to learn with that, even to do that, well. So, you know like evening classes where they teach hobbies how to solder. But that doesn't mean they going to be able to sell their stuff for 10 thousand pounds, they are still hobbyist. I think that 3D printing at home will be that way, maybe. I think that a lot of people thinks there is a quick solution to something. Something like great I will 3D scan this and then 3D prints it. But there are a lot of programmes you need to know; how to export from one program to another, how to clean it up... you know is not as easy and simple as you think.

29:32.8 - 30:09.0 Why would you need to be worried about it?

3D printers taking part of your everyday, or your practice.

30:09.0 - 33:16.6 At the Royal College, it was interesting because many people came from many departments, my department was called Goldsmithing Silversmithing Metalwork and Jewellery. Yet the RC has an open-door policy so I was always down at product design or textiles. You could use anything. There were designers and architects doing jewellery, they didn't need to know about the process but about the materiality of it. Back in the day it was all this wonderful crafts people so gifted no one could ever rival their skill but now there are some things that can rival their skill. The technology means that people that are architects or whatever, if you know how to use rhino they can create objects and jewellery objects. It could be anything really, so they don't need to have the traditional background of metal working... but then they are different objects [referring to mechanical reproduction as compared to handcrafted] and it is cool as well, I mean I have done it as well. and some of the works are great. But then, there are more designers in a way.

There are people that use both, like me. And there is people that really love making by hand. I think the market is just different. Because, there is some people that wants stuff that has been handmade, they are real snobbery for that. I don't think they are not the majority. There is people that wants a thing and they don't care about how it is made. And that has been always there. Like industrial design some people want a chair or sometimes they want the design classic.

We are all designers but I think it is a different thing and We just need to move on...

33:16.6 - 33:21.9 Do you think that there is people that is worried about this technology becoming available for everyone?

33:21.9 - 36:01.8 I think they probably are. I have friends in the industry which are in their 60s, they are not going to learn it. So, there will be companies that overtake them, they can produce faster. If it is a small company it could pose a challenge for them, but bigger companies have already embraced, like casting companies and jewellery they all embrace the digital stuff. I guess like photographers had to embrace digital.

I don’t know.

If you look at the industrial revolution, many years ago, some people though that craft was lost because of the machinery. But for me that realises the craftsperson, because if someone is a thinker and they want to be pushed to have ideas... that is great, the monkeys work machines do the job and do their repetitive stuff and then they can go with other things. In some ways I think the technology helps me to do that, because I feel like I am an slave to some of the techniques, the more success I got the more resent I get because I will be bored of having to remake things, I don’t know this makes me not to fear them but to be challenged and not just being a machine yourself, so this can help, you can repeat without going crazy or losing the integrity, because it has all been done in a digital form before, I think it is a good compromise I am all about progress.

10.5. APPENDIX E: PORTFOLIO

BENDING TECHNOLOGY
/
A COLLABORATIVE APPROACH TOWARDS DIGITAL FABRICATION

// DIEGO ZAMORA BARROSO

Thesis submitted for the Degree of Doctor of Philosophy

PORTFOLIO

The University of Edinburgh
Edinburgh College of Art
PhD

/ January 2018

/ WORKSHOPS

/PRINT3D WORKSHOPS

The images presented here are part of the creative explorations that happened during the workshops. They represent the activities and often the discussions and challenges that emerged as part of this creative exploration of 3D printing and collaboration.

Next page, Size does not matter: overcoming dimensional constrains by appropriating outdoors textures and public spaces.

Left and bottom, "does it have that handmade quality?"

Next page, hands-on collaboration.

Left, “does it have that handmade quality?”. By exploring the processes of clay modelling and digitalisation with 3D scanners participants were able to analyse how to what extension the trace of the hand can be explored within a digital domain.

Right, Half eaten chocolate bars. Participants participated in a range of activities with scanners and computer aided design tools. However, the most compelling explorations were the ones that were done while “playing” with the technologies. These chocolate bars were transformed into brooches with the help of a hot glue gun.

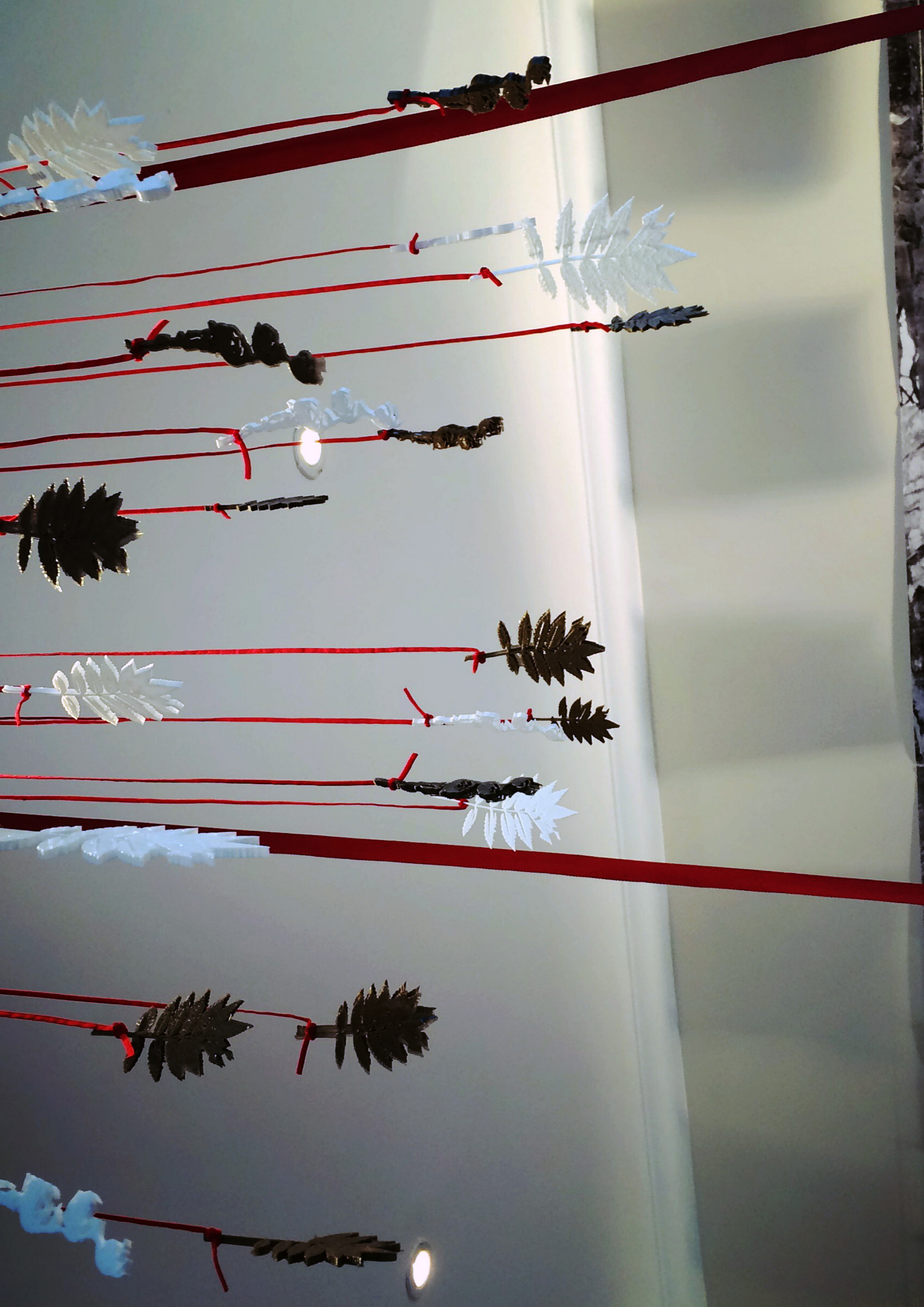
/ COLLABORATIONS

/EMBROIDERY AND 3D PRINTING; JEN DESCHENES

This collaboration started after meeting in a workshop. Originally we intended to create beads for embroidery, however, the desktop 3D printers I could access were not able to produce model with enough detail for that. Thus, we approached embroidery from a different scale. Here I present the ideas and concepts Jen developed with my help. My participation consisted mainly of the generation of 3D models and 3D prints based on images that she provided.

Left, Vectorised image.

Left and below, images of natural elements to be used for 3D printing.

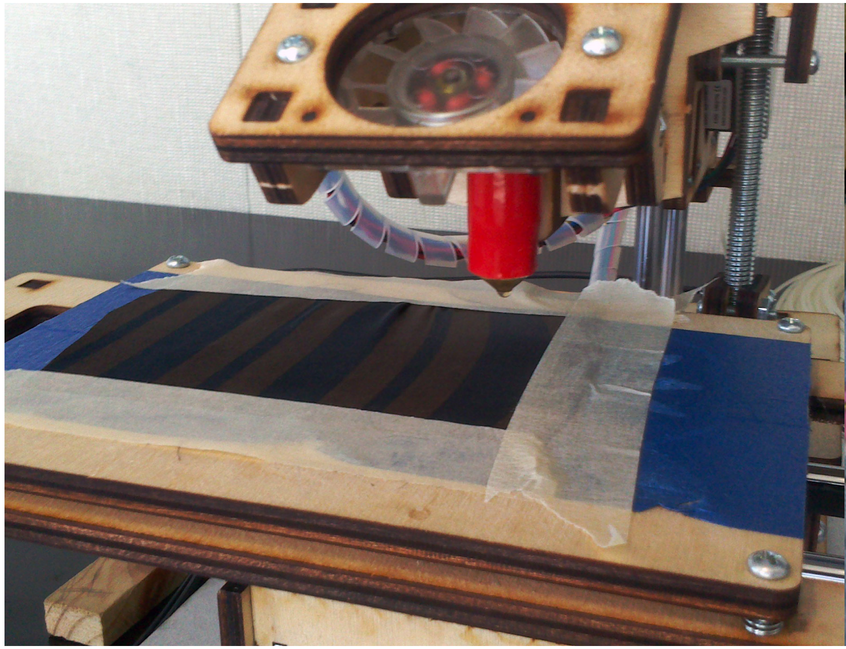


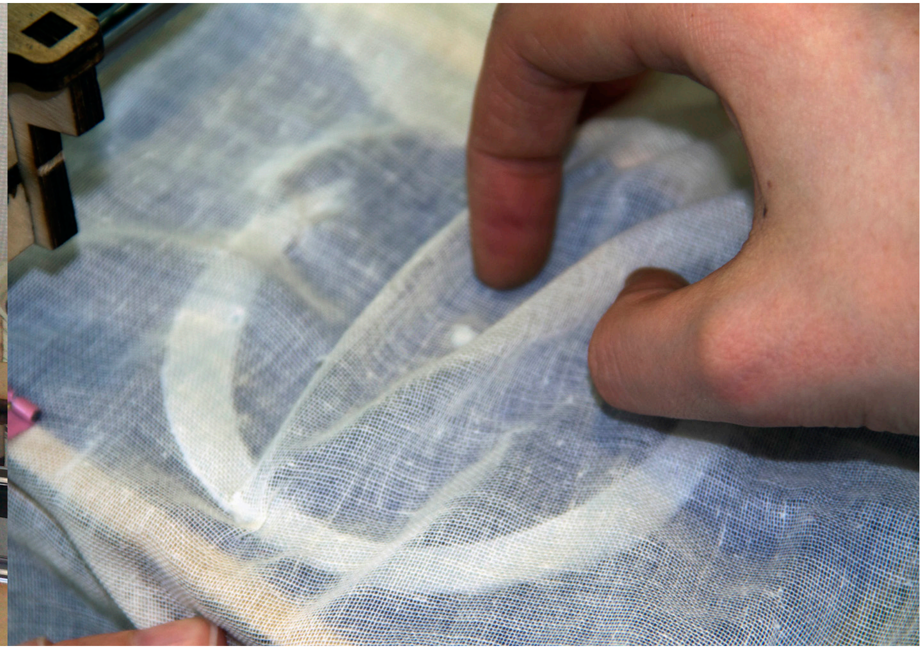
Previous page, left, exhibition Stories from the Glen, natural charms are used to re-tell the local history through innovative processes and materials; 3D prints, threads and linen.

Previous page, right and this page, A sailor went to sea exhibition, 3D printed knots onto traditional embroidery. Common nautical knots are 3D printed in order to re-mediate a process. This is done in the form of nautical charms and memoranda.

/WEAR3D; MORVERN ODLING

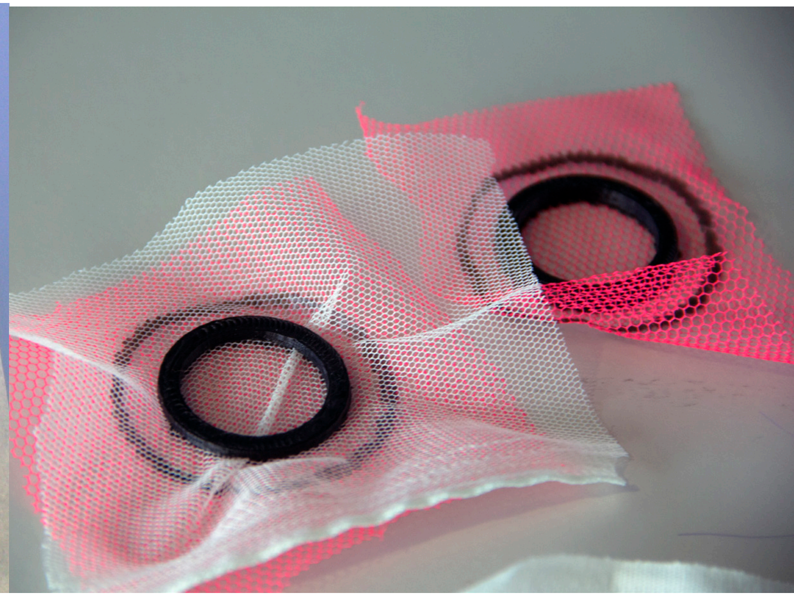
This collaboration started after meeting by chance. Our intention was to generate a process that anyone could appropriate or use as part of their creative inquiry into 3D printing and textiles. The two processes developed provide opportunities for expanding the dimensional constrains of desktop 3D printers as well as potentially making any 3D model into a wearable.





Previous page, mountains on fabric. Transferring 3D models into fabric.

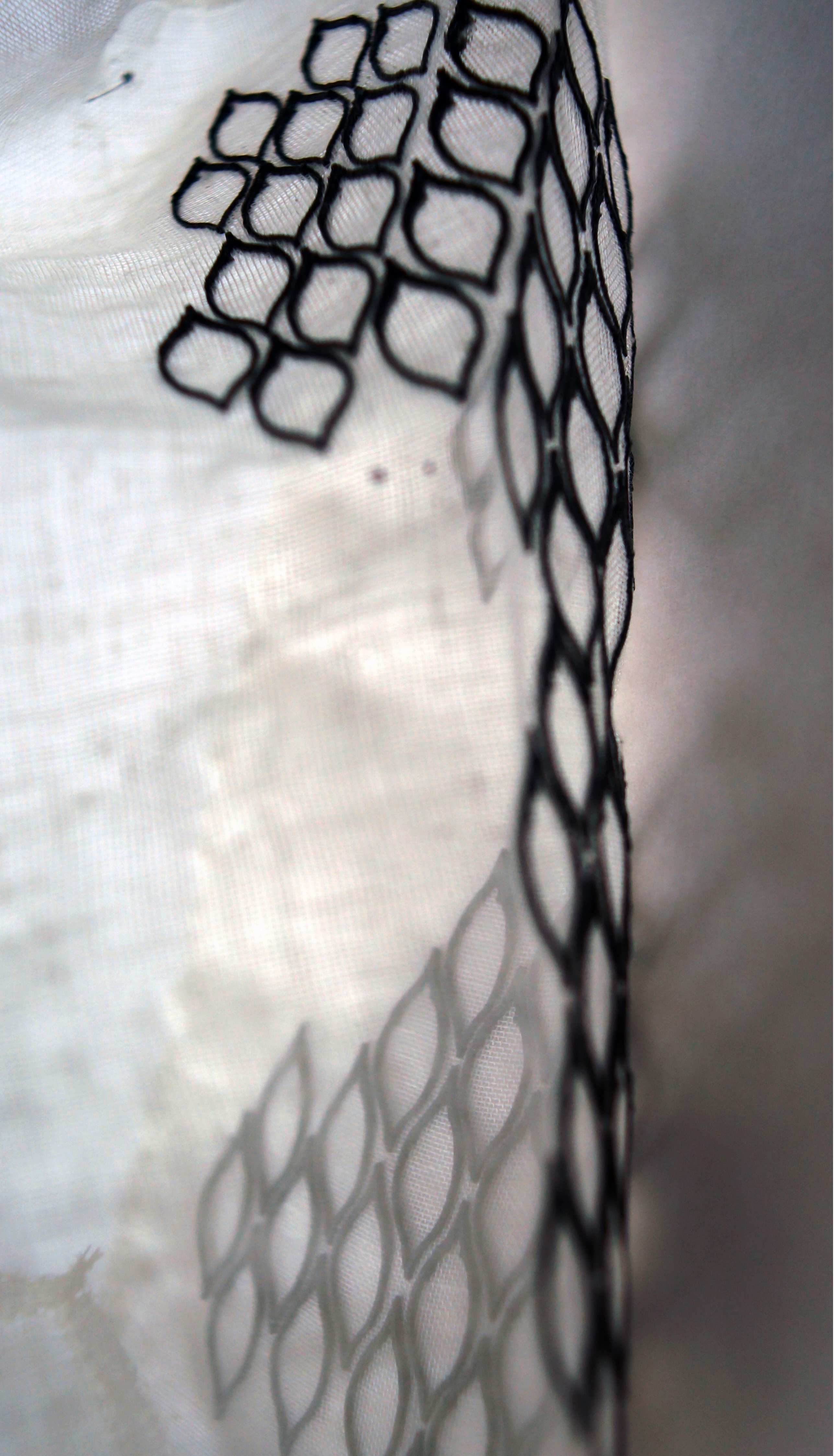
This page, process of designing, clamping and printing into fabric. First successful experiment at capturing fabric into PLA.



Left, first wearable, PLA onto open weave linen.

Below, Trapping of fabric on PLA.

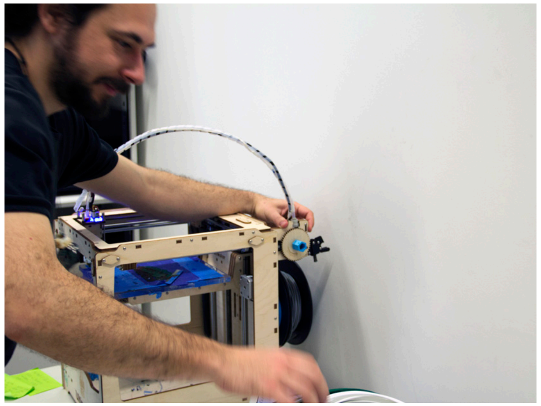
Next page, sensual exploration of transparency and very light printing, PLA and fabric.

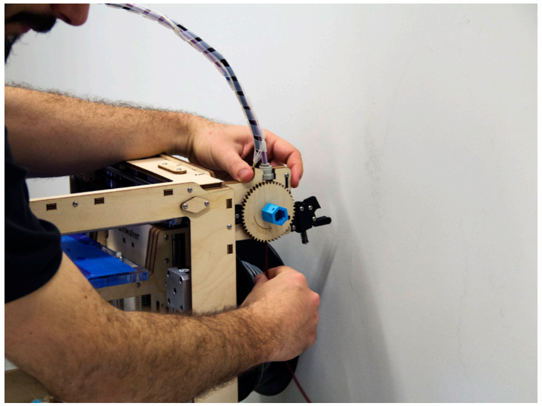


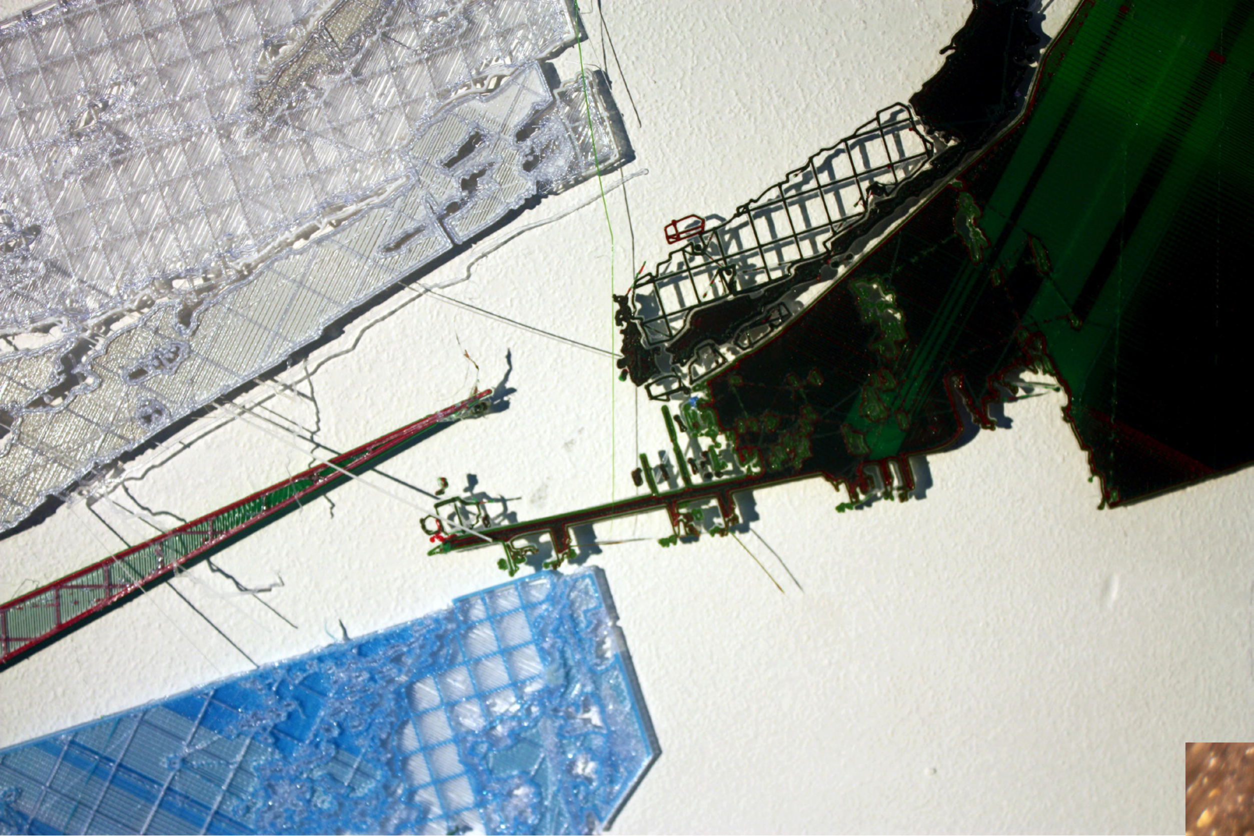
/NOTTOBEREPRODUCED; MARK CONNOLLY

Nottobereproduced started as funded residency for ICT-ART connect initiative. Our intention was to re-mediate Marks appropriation of social media content into 3D printing. However, the process evolved to generate more interesting interactions among ourselves and with the technology we were using. For me, it changed 3D printing, for him, it changed painting. Through iterative development we reach a point of mutual reinterpretation were he painted something and I challenged it through 3D printing, were I 3D printed he reinterpreted it into painting. This collaboration produced two outcomes; the exploration of the relation between 3D printing and painting, and the appropriation of 3D printing by products (i.e. support material and infill).

In addition to that, I developed an intimate relation with the 3D printing by developing a process by which I manipulated and altered the process of 3D printing on the flight. This led to a tacit understanding of the process of 3D layering. This is explored through unfinished and colourful 3D prints using a single filament desktop 3D printer.



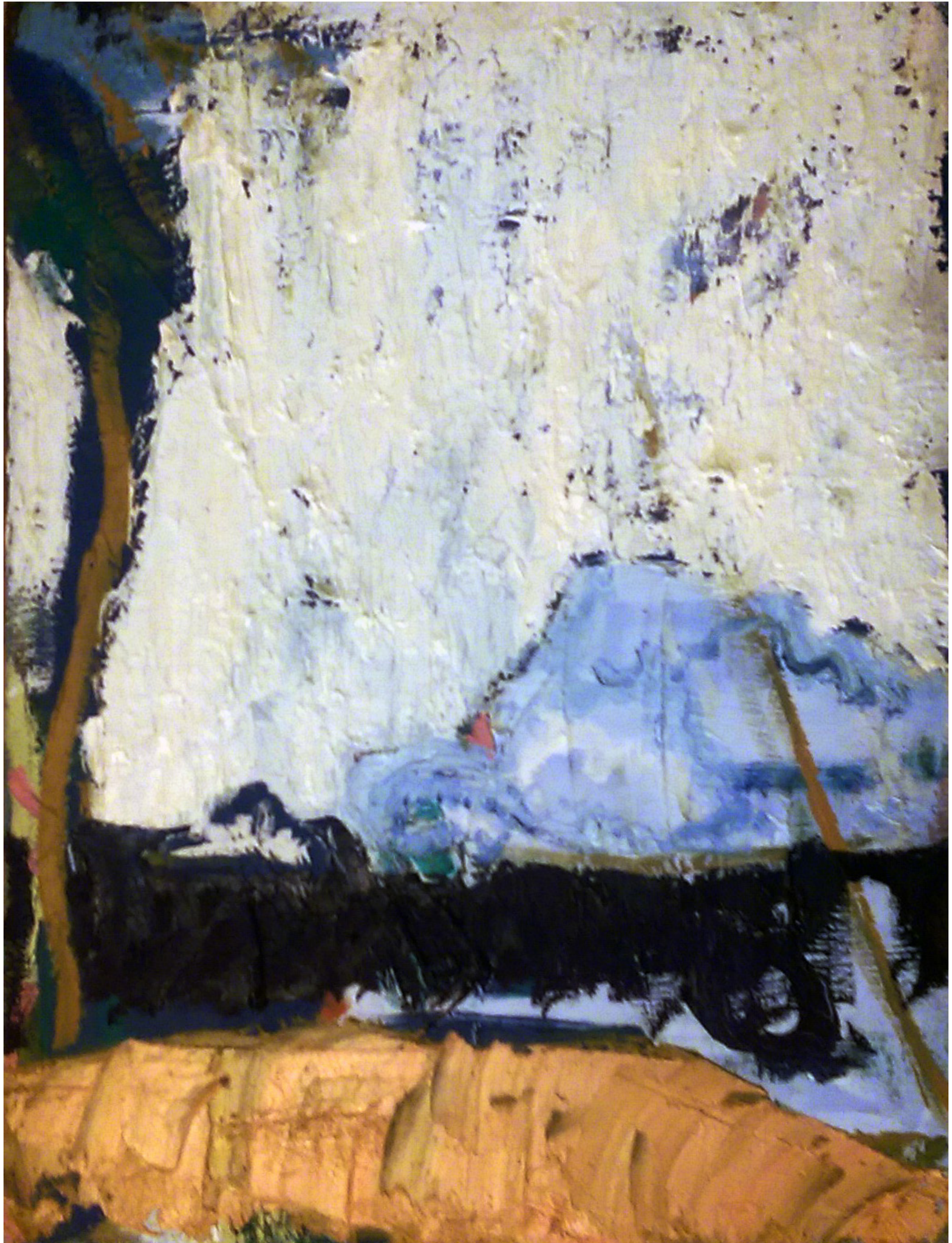




Previous page, errorful creations 1, through a series of wrongly made we explored the role of errors within our practices. Thereafter rather that removing support material or overflowed plastic we started designing so our pieces would present those errors as part of the aesthetic narrative.

Left, composition on wall of various hands-on 3D prints.

Below and next page, structural relation between a 3D print and a painting. Painting by Mark Connolly, 3D print by Diego Zamora.



This page and next, collage re-mediated. The 3D print is the result of the combination of appropriated images that were transformed into 3D objects, then combined to form a distorted space. This piece is held together by the support material, without it would crumble down. This was reinterpreted into a painting presented here. Painting by Mark Connolly, 3D print by Diego Zamora.